

**AGRICULTURAL SUSTAINABILITY OF SMALLHOLDER FLOODPLAIN
AGRICULTURAL SYSTEMS: A CASE STUDY OF *FADAMA* AREAS IN
NORTH-CENTRAL NIGERIA**

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Declaration

I hereby declare that this submission is wholly and to the best of my knowledge the outcome of my research and I am its sole author. This thesis does not contain any material previously published or accepted for any award. Where other sources of information have been used, they have been properly acknowledged. I understand that my thesis may be made electronically available to the public.

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Abstract

In the aftermath of the global food crisis, great debates have arisen on the future of African agriculture. The crisis has once again raised the question of food security on the continent. Previous approaches aimed at increasing the agricultural productivity of farmers have failed. This has necessitated a call for a change of approach in which smallholders, who are the bulk of Africa's food producers, will play a pivotal role. The main challenge facing the continent is how to balance the quest for food self-sufficiency and the demands of sustainability. This thesis is a concrete contribution in the quest for productive yet sustainable food systems in Africa. It surveys and analyses the sustainability of *fadama* (floodplains) farming systems of Northern Nigeria. Strong emphasis is placed on the socio-economic, institutional and demographic drivers affecting productivity and sustainability of *fadama* agriculture. Findings reveal a delicate interaction and negotiation across the formal and informal boundaries where traditional agricultural practices, based on an understanding of the particular physical reality and exploitation of natural synergies, are combined with inputs typical of conventional agriculture. African agriculture thus stands poised at crossroads; whether to abandon tradition in favour of entirely 'modern' methods and export markets as often advocated for in certain circles or depend on time tested indigenous knowledge systems and grassroots-defined development vision which combines popular livelihoods with respect for nature's systems. Drawing on Bruno Latour, the metaphor of 'hybridisation' is used to justify a negotiated compromise between official discourses, which promote the use of chemicals and grassroots reality which relies on nature's systems. Agroecology is offered as a model to overcome this agricultural dualism (inputs vs. tradition) through combining compatible elements of the two systems for greater productivity and sustainability. However, the key question of how agricultural hybridization should take place remains unresolved in this thesis for whereas it appears feasible in certain areas such as knowledge and institution sharing, in others such as the use of external inputs, the two systems appear irreconcilable.

Dedication

To my parents, Joseph and Hamsatu Dan-Azumi, the two most special people in my life for their diligence, guidance, advice and love and for teaching me the first lessons on sustainability and efficient use of nature's resource.

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List of Acronyms

Acronym	Definition
ACGS	Agricultural Credit Guarantee Scheme
ACTAF	Asociación Cubana de Técnicos Agrícolas y Forestales (Cuban Association of Agriculture and Forestry Technicians)
ADB	African Development Bank
ADP	Agricultural Development Programmes
AERC	African Economic Research Consortium
AERLS	Agricultural Extension Research And Liaison Services
AIDS	Acquired Immune Deficiency Syndrome
AKST	Agricultural Knowledge, Science and Technology
ANAD	Asociación Nacional de Agricultores Pequeños (The National Association of Small Farmers)
ARTP	Agricultural and Rural Transformation Programme
BLP	Better Life Programme
BT	<i>Bacillus Thuringiensis</i>
CAADP	Comprehensive Africa Agriculture Development Programme
CAFO	Concentrated Animal Feeding Operation
CARD	Cooperative And Rural Development
CATPRN	Canadian Agricultural Trade Policy Research Network
CBN	Central Bank of Nigeria
CCIC	Canadian Council for International Cooperation
CDD	Community Drive Development
CGIAR	Consultative Group on International Agriculture Research
CIRAD	Centre de Cooperation Internationale en Recherche Agronomique pour le Developpement
CPRC	Chronic Poverty Research Centre
CRIST	Crops Research Institute for the Semi-Arid the semi-arid Tropics
DDT	Dichloro-Diphenyl-Trichloroethane
DDFRI	The Directorate of Food, Roads and Rural Infrastructure
DFID	Department For International Development
DIIS	Danish Institute for International Studies
ECA	Economic Commission for Africa
ECOWAS	Economic Community Of West African States
ERP	Economic Recovery Program
EU	European Union
F&F	Faith and Faith
FAO	Food and Agricultural Organization
FAOSTAT	The FAO Statistical Database
FARO	Federal Agricultural Research <i>Oryza</i>
FCA	<i>Fadama</i> Community Association
FCT	Federal Capital Territory
FEAP	Family Economic Advancement Programme
FMARD	Federal Ministry of Agriculture and Rural Development
FOS	Federal Office of Statistics
FSP	Family Support Programme
FTI	Factual Technical Information
GDP	Gross Domestic Product
GE	Genetic Engineering
GHI	Global Hunger Index
GMO	Genetically Modified Organisms

Acronym	Definition
GNI	Gross National Income
GR	Green Revolution
GT	Grounded Theory
HDI	Human Development Index
HIV	Human Immunodeficiency Virus
IAASTD	International Assessment of Agricultural Knowledge, Science and Technology for Development
IAR	International Agriculture Research
IATP	Institute for Agriculture and Trade Policy
ICAARD	International Conference on Agrarian Reform and Rural Development
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDS	Institute of Development Studies
IFAD	International Fund for Agricultural Development
IFOAM	International Federation of Organic Agriculture Movements
IFPRI	International Food Policy Research Institute
IIED	International Institute for Environment and Development
ITTA	International Institute for Tropical Agriculture
IK	Indigenous Knowledge
IKS	Indigenous Knowledge Systems
ILO	International Labour Organization
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
IPFPRI	International Food Policy Research Institute
IPM	Integrated Pest Management
IRAT	Institut de Recherches Agronomiques Tropicales
JICA	Japanese International Cooperation Agency
LDC	Less Developed Country
LIFDC	Low Income Food Deficit Country
MDG	Millennium Development Goals
NAFDAC	The National Agency for Food and Drug Administration and Control
NAFN	National Agricultural Foundation Of Nigeria
NAFTA	North American Free Trade Agreement
NARCDDB	Nigerian Agricultural Cooperative and Rural Development Bank
NBS	National Bureau of Statistics
NDE	National Directorate of Employment
NEEDS	National Economic Empowerment Development Strategy
NEPAD	New Partnership for Africa's Development
NERICA	New Rice For Africa
NFDO	National <i>Fadama</i> Development Office
NFDP	National <i>Fadama</i> Development Project
NPC	National Planning Commission
NSS	National Seed Service
NWRMP	National Water Resources Master Plan
ODA	Overseas Development Assistance
ODI	Overseas Development Institute
OECD	Organisation for Economic Co-operation and Development
OFN	Operation Feed the Nation
PAN	Pesticide Action Network
PANNA	Pesticide Action Network North America
PAP	Poverty Alleviation Programme

Acronym	Definition
PPP	Purchasing Power Parity
PRSP	Poverty Reduction Strategy Paper
R&D	Research and Development
RBDA	River Basin Development Authority
SAP	Structural Adjustment Programme
SSA	Sustainable Smallholder Agriculture
T&V	Training and Visit
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNCTAD	United Nations Conference On Trade And Development
UNDP	United Nations Department For Policy
UNECA	United Nations Economic Commission For Africa
UNEP	United Nations Environment Programme
UNFPA	United Nations Population Fund
UNRISD	United Nations Research Institute For Social Development
UNSCN	United Nations Standing Committee On Nutrition
USAID	United States Agency For International Development
USDA	United States Department of Agriculture
WARDA	West Africa Rice Development Association
WB	World Bank
WDR	World Development Report
WFP	World Food Programme
WHO	World Health Organisation/Food
WTO	World Trade Organization

CHAPTER 1

INTRODUCTION

1.1 Background: Research Problem

Fadama is a Hausa¹ word for wetlands or the seasonally flooded or floodable floodplains along major savannah rivers and/or depressions on the adjacent low terraces. At the beginning of the wet season, they are marked by a lush of new vegetation before the upland turns green (Turner, 1977). Nigeria is endowed in underground and surface water reserves, rich pastures and favourable agro-ecological conditions in the country's low lying plains with alluvial deposits. There are over 3,000,000 ha of the fertile soils with residual moisture in the dry-season which are extensively used by smallholders for crop and livestock production. Due to the high moisture retention capability of the floodplains, they are widely and increasingly used for recession farming (*noman rani*). Thus, *fadamas* are of critical importance to the survival and economic development of smallholders especially in the savannah regions of Nigeria. It is an important safety net for the rural poor and constitutes a major alternative source of food supply, especially in times of drought, during the dry season, or failure of upland crops.

Farming families engage in subsistence farming in which family needs determine the scale of production and wherein small plots of land are cultivated by individual owners or sub-owners using age-old methods of soil and water management. Traditionally, many families have cultivated small areas in the *fadamas* during the dry season using water drawn manually from shallow wells or streams. Family farming uses mainly family labour which could be augmented with minor hiring of labour and labour exchanges with other farmers at peak seasons. The essential factors of production – land, labour, and capital are provided within the family.

However, *fadama* lands are under pressure from natural and man-made factors that include rapid population growth, drought, land degradation, expansion of cultivation on fragile forest cover, soil erosion, loss of soil fertility on arable lands, insufficient food production (FAO and IITA, 1999; Ewuim et al., 1998). Other pressures faced by smallholders in *fadama* areas are conflicts arising from competing land uses, intensification of agricultural activities by farmers, pastoralists, fisher-folks and other *fadama* users (Ardo, 2004). Faced with the dual problem of structural poverty and hunger, aggravated by the pressures mentioned above, smallholders in Northern Nigeria are continually seeking new ways to survive and protect their livelihoods.

¹The language (Hausa) is a Chadic language belonging to the Afro-Asiatic language family and it is one of the three major languages spoken mostly in Northern Nigeria and across West Africa.

Agricultural policies in Nigeria have generally followed the path of modernism, i.e. the desire to break up with the past (traditional agriculture) which is considered to be archaic and unproductive. Agricultural modernization was and is still regarded as the key to achieving food security and economic growth. Previous policies and programmes targeted at improving the productivity of smallholder *fadama* farmers relied on technical assistance through the provision of external inputs such as fertilizer, herbicide, insecticides and hybrid seeds. Others include large-scale irrigation schemes aimed at transforming small-scale agriculture to commercial farming.

The result of these various intervention measures include: the erosion of sustainable traditional farming practices (intercropping, mixed cropping, integrated farming, and use of organic manure); widespread adoption of agrochemicals and the attendant environmental consequences and food scarcity as a result of emphasis on crops for the market as against food crops. Farming systems that dwell more on export crops and agricultural commercialization were generally given precedence over smallholder, family-based production capacities despite their predominance in the food production chain. Export agriculture became more entrenched at the expense of national food self-sufficiency. The effect of these policies is that research and extension have targeted and served the interest of the ‘modern’ agriculture and the ‘modern farmer’ instead of improving the indigenous practices of the smallholder farmer. Generally, these policies have not resulted in long-term sustainability and food self-sufficiency, nor have they led to poverty reduction, especially among Nigeria’s teeming rural populations.

The increasing importance of *fadamas* for food production and economic development, as well as the need for sustainable development of the agricultural sector make this study very useful. Equally important is the ecological significance of *fadama* areas. Some scholars have argued that unsustainable agricultural practices have contributed to the poor agricultural productivity in Nigeria (Ikpi, 1995; Ayuk, 2001). Additionally, the study is important given increasing pressures on agricultural lands in Nigeria due to factors that include: climatic changes (for instance drought and erratic rainfall), rising food prices, environmental risks associated with conventional agriculture² and population growth (Adams and Carter, 1987; Morgan and Solarz, 1994; Vaishnav, 1994; World Bank, 2001). *Fadama* agriculture provides an excellent example of how African smallholders meet the challenge of productivity and sustainability in an ever changing environment.

² Throughout this thesis, conventional agriculture is used interchangeably with modern agriculture to refer to an “industrialized agricultural system characterized by mechanization, monocultures, and the use of synthetic inputs such as chemical fertilizers and pesticides, with an emphasis on maximizing productivity and profitability. Industrialized agriculture has become “conventional” only within the last 60 or so years (since World War II).”

1.2 Importance of Study

Despite divergent and often conflicting views with regards causes and solutions, there is a general consensus that the global food system is in serious crisis. Factors such as climate change and increasing population, among others, are transforming the world food system and could trigger a major global food crisis in the next fifty years. Millions of vulnerable people around the world are facing starvation due to food shortages and increased food prices. Overall, the poorest people in developing countries who rely on marginal lands to grow crops and rear animals and who spend most of their income on basic food commodities and are the most affected by this situation. This problem is, however not limited to the developing world as experts have shown that the impact of this crisis is spreading to developed countries.

Like many developing countries, Nigeria faces fundamental challenges with regards to food security. Although domestic food production is said to be on the increase, it is grossly inadequate in meeting the growing food demand in the country. Despite huge budgetary allocation, food supply in Nigeria is short, unstable and inaccessible and food deficiency diseases are on the increase. Nigeria hugely depends on food imports to meet its food deficit and the country's current annual food import bill stands at \$3b (Davidson and MacEwen, 1983). In the first quarter of 2008, the Nigerian government approved plans to import 500,000 tonnes of rice estimated to cost US\$600 million in order to meet higher rice demand in the aftermath of the global food crisis (Warburton, 1998). This unbridled food import is disturbing given that Nigeria is endowed with favourable agro-ecological climate and the resources needed for optimum food production. This thesis is a concrete study aimed at contributing to the search for sustainable and productive food systems for greater food security and poverty reduction.

One area that holds great potential for improved food production in Nigeria is the *fadama* land. Of the total land used for rice cultivation in Nigeria, 35% is under swamp and *fadamas* (Oputa et al., 1985). Thus, *fadama* areas have the largest share of rice area and production and the highest priority for reduced production cost (table 1). Other crops grown in the *fadama* areas are maize, sorghum, guinea corn, yam, cowpea, beans and sugarcane. *Fadama* lands (because of their high water table) present a vast potential for improving agricultural production in order to meet the food security needs of the people as well as increase the remuneration of the smallholder farmers who cultivate these areas.

	Area (000 ha)	Area Share	Yield (mt/ha)	Rice (000 mt)	Production Share
Upland	493	30%	1.9	562	28%
Lowland	854	52%	1.7	871	43%
Irrigated	263	16%	3.7	583	29%
Mangrove	16	1%	2.0	20	1%
	1,642		2.1	2,036	

Table 1: Contribution of main rice ecologies to the rice-subsector in Nigeria
Source: (Erenstein et al., 2003)

However, despite their huge potential for increased agricultural productivity, *fadama* areas are fragile and the manner in which they are utilized has very important environmental and health ramifications because of the high levels of underground and surface water in those areas. Over the last four decades, substantial parts of the *fadama* ecosystem and indeed *fadama* agriculture have been significantly modified or completely eroded.

Secondly, this research is important because it focuses on smallholder farmers, which is one of the most persistent groups in Nigeria. Yet, this group has been described as the most disadvantaged and vulnerable with high levels of poverty. Studies (between 1994 and 2004) have shown that the bulk of people living in absolute poverty in Nigeria are smallholders living in rural areas (Apata et al., 2009). This study investigates how smallholder *fadama* agriculture really works, its sustainability and the dilemma facing smallholders as well as the factors that underline their decisions to accept, reject or modify elements of conventional agriculture.

1.3 Research Purpose and Scope

This research will address the challenge of food security and sustainability in Africa from a social and institutional perspective with agricultural science built into it as a specialist input. This is done with special reference to smallholder agriculture which is the source of livelihood for an estimated 86 percent of rural people. It provides jobs for 1.3 billion smallholders and landless workers, “farm-financed social welfare” when there are urban shocks, and is a foundation for viable rural communities. Of the developing world’s 5.5 billion people, 3 billion live in rural areas, nearly half of humanity. Of these rural inhabitants, an estimated 2.5 billion are in households involved in agriculture, and 1.5 billion are in smallholder households (World Bank, 2007b, p. 3). Thus, this research seeks new insights into the role of smallholder agriculture in food security and poverty reduction developing countries.

This research hopes to contribute to the debate on agricultural sustainability and productivity in Nigeria. It is principally exploratory and strives for a better understanding of what is happening in smallholder *fadama* farming communities. The study focuses on the savannah regions of Northern

Nigeria and explores the farming practices of *fadama* users in light of biophysical/social factors and reduced government subsidies on agricultural inputs with the purpose of ascertaining their sustainability. In general, literature and research on agricultural sustainability in Nigeria are few. Also, the response of smallholders to agricultural dualism (modern vs. traditional) has not been adequately explored. This research will investigate the role of smallholders and indigenous knowledge play in food security and poverty reduction in Nigeria.

Furthermore, this study seeks to explore the relationship between modernization and agricultural policies pursued in Nigeria. Government strategies for agricultural development are reviewed with the specific aim of showing the policy direction of the Nigerian government with relation to agricultural sustainability indigenous knowledge systems, modernization and commercialization. Some of the policies reviewed include: the building of dams for irrigation purposes and the introduction of input packages and if these measures have led to substantial increase in smallholder production.

1.4 Research Question and Objectives

The primary question this research hopes to answer is: How sustainable is smallholder agriculture? Principally, the research will seek to establish the relationship between smallholders, sustainability, productivity and poverty reduction in North-Central Nigeria. The particular questions specific to this case study will include the following: how sustainable and productive are *fadama* farming practices? What is the role of *fadama* agriculture in ensuring food security and reducing poverty? How do *fadama* farmers respond to agricultural intervention policies (e.g. the introduction of new technologies)?

The study will also examine institutions (formal and informal) and social structures and how they relate to agricultural production/sustainability among smallholder farmers in North-Central Nigeria. It will assess the sustainability of *fadama* farming using agro-ecological parameters of reduced external inputs and increased dependence on ecological relationships and processes for increased food production and fewer negative environmental impacts. Thus, the study will focus on traditional agricultural practices of *fadama* farmers for soil and water conservation and management. Secondly, this study will investigate the extent of agrochemicals/machinery use in *fadama* agriculture. Therefore, this study will analyse current practices of *fadama* farming with a view to understanding their potentials as well as their present and future implications for the environment and the broader question of food security. These aims will be achieved through the following specific objectives:

1. To survey the current socio-economic background and demographic drivers characterizing *fadama* agriculture as well as the problems arising thereof
2. To determine *fadama* farmers' strategies for soil and water management (biomass recycling, enhancing soil biotic activity, minimizing water/air/nutrient loss, ecosystem diversification, enhancing biological synergisms
3. To investigate the productivity of *fadama* systems
4. To determine the extent of agro-ecosystems dysfunction in *fadama* farming through use of fertilizer/pesticides, monoculture, low functional biodiversity, genetic uniformity (hybrid seeds) and nutrient deficiencies
5. To investigate the determining factors leading to adoption of external input based agriculture
6. To contribute in designing a more sustainable global food and agricultural system

1.5 Structure of Thesis

This thesis is organized into seven chapters. In Chapter 2, the case study introduced above is contextualized to show the background to the research. Hence, the history and trend of agricultural intervention in Nigeria from 1960 to date is investigated. Similarly, the practice of *fadama* agriculture is explored within a wider global context to show its benefits to smallholders in many parts of the world. Chapter 3 explains the philosophy behind the research as well as the research design and provides justification for choice of methodology and methods of data collection utilized in this research. Also, the place of literature in the research as well as the process of data analysis is explained. In chapter 4, results from the fieldwork are presented and analysed in-depth to reveal the delicate balance between traditional and conventional agriculture in *fadama* areas and the point of contact between the formal sector (typified by the Nigerian government, non-governmental organizations (NGOs), institutions of global governance, the elite, policy makers and some segment of the academia) and the informal sector (constituted by smallholders and rural dwellers). Chapter 5 examines the constraints to productivity and sustainability in *fadama* areas and offers some recommendations on how these constraints can be addressed so as to achieve the twin goal of productivity and sustainability. Chapter 6 draws from the ideas of Bruno Latour and develops a theoretical basis (from results and findings) for thinking about sustainability where the best of local indigenous knowledge systems and conventional agriculture are combined to ensure food security and environmental integrity. This is what is referred to as *hybrid* development. Finally, in Chapter 7, a conceptual framework is developed through a careful review of the literature in order to provide the context within which to interpret research results. Firstly, a critique of the global food system is

made in order to show the challenges it faces with regards consumption, production and trade. Furthermore, the concept of agricultural sustainability is explored as well as alternative models of sustainable agricultural production. Specifically, agroecology is discussed as a multi-dimensional and sustainable alternative to conventional agriculture. Secondly, the literature on smallholders is reviewed to show their place in food production and agricultural sustainability. Finally, the vital role that women play in agriculture in developing countries is critically reviewed.

CHAPTER 2

CASE-STUDY OVERVIEW: NIGERIAN AGRICULTURE AND FOOD SECURITY CHALLENGES

2.1 Introduction

In this chapter, a background to the case study is provided. The dynamics (issues and challenges) of Nigerian agriculture are discussed and the national agricultural development strategies and policies from 1960 to 2000 are reviewed highlighting their impact and the role of previous and present organs of government. A review of the literature shows that Nigerian agriculture has performed poorly since the 1960s resulting in declining gross domestic product and export earnings, mounting food deficits, soaring retail food prices and import bills, environmental degradation, the erosion of smallholder agricultural knowledge systems and more poverty among rural dwellers. The failure of the Nigerian government to develop its agricultural sector despite huge oil wealth will be discussed. This chapter posits that agricultural development in Nigeria has almost exclusively followed the route of technical expansion to achieve agricultural development. It lacks a systematic policy regarding smallholders and agricultural sustainability.

Secondly, the nature and characteristics of floodplains (*fadama*) are discussed to show their importance and relevance to the livelihoods of millions of smallholders around the world, particularly in developing countries. A historical appraisal of *fadama* agriculture in Nigeria is made in order to show the impact of agricultural policies on *fadama* ecosystem and farming systems. The discussion on Nigeria's *fadama* areas is done within the context of changes in the general structure of Nigerian agriculture due to climate change, decline in the amount of land available for agricultural production (due to high rates of deforestation, desertification, overgrazing and soil erosion among others) (Osemeobo, 1988) and the oversubscription of land resources (soil and plants) beyond their carrying capacities (FMA, 1983).

2.2 Overview of Nigeria's Agriculture and Food Security Situation

Despite its huge oil reserves, agriculture is one of the single most important sectors of the Nigerian economy and contributes significantly (over 70%) to the total annual GDP. It is the largest job providing sector, employing about 70 per cent of the labour force and accounting for over 70 per cent of thenon-oil exports. More importantly however, agriculture provides over 80 per cent of the domestic food needs of the country's over 130 million people (Adegboye, 2004). As of 2000, Nigeria had one of the largest regional shares of agricultural gross domestic product in Africa (AgGDP) (FAO, 2003a).

Until the mid-1960s, Nigeria's share in world agricultural export was more than 1 per cent and it supplied more than half of all traded palm kernel, more than a third of all groundnuts and more than a fifth of all palm oil. However, since the 1980s, Nigerian agricultural export has declined as the nation's economy became heavily dependent on petroleum exploitation (fig 1). This decline has been blamed on reduced farmer incentives, neglect of agricultural infrastructure and poor economic environment. Nigeria's world market share for agricultural products now stands at less than 0.1 per cent (Walkenhorst, 2007).

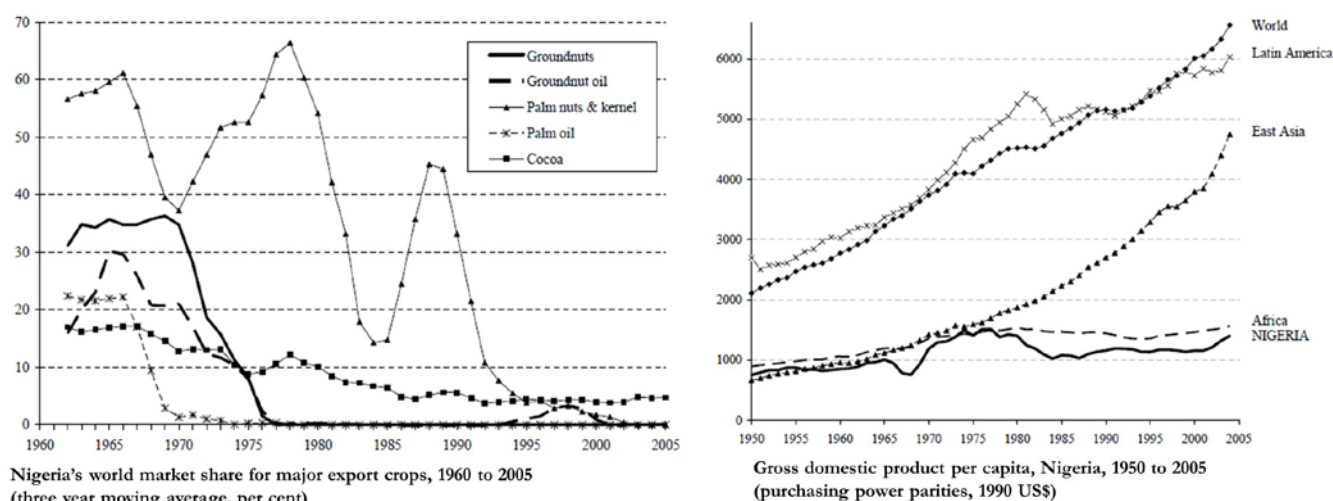


Figure 1: The performance of Nigeria's export agriculture
Source: (Walkenhorst, 2007)

With a score of 18.43 on the GHI³, Nigeria is ranked high among countries with serious hunger crisis. Similarly, the recent food crisis has impacted heavily on the poor and small-scale farmers who form the bulk of the food producers in Nigeria. The FAO lists Nigeria among the nations that are technically unable to meet their food needs from rain-fed production, a trend likely to remain so even at the intermediate levels of inputs at some time between 2000 and 2025 (NINCID, 2005). Thus, Nigeria depends on commercial food import to fill the gap in supply deficit (table 2). “Between 1973 and 1980, a total of 7.07 million tons of wheat, 1.62 million tons of rice and 431,000 tons of maize were imported. From N47.8 million in the 60s, the cost of food imports in Nigeria rose to N88.2 million in 1970 and N1, 027.0 million in 1988” (Alkali, 1997, pp. 19-21). In 1982, Nigeria imported 153,000mt tons of palm oil at the cost of 92 million USD and 55,000mt tons of cotton valued at 92 million USD (Alkali, 1997, p. 10).

³The three indicators are:

1. The proportion of people who are calorie deficient, or undernourished, which is a key indicator of hunger.
2. The prevalence of underweight in children under the age of five, which is a measure of childhood malnutrition—children being the most vulnerable to hunger.
3. The under-five mortality rate, which measures the proportion of child deaths that are mainly caused by malnutrition and disease

	1994	1995	1996	1997	1998	1999	2000	2001
Shortfall (Deficit)	0.53	0.30	2.91	3.34	3.13	4.22	5.34	6.51
Food Import	0.67	0.58	2.95	3.47	3.24	4.48	5.59	6.91

Table 2: Food shortfall and import, million Mt (1994-2001)
Source: Review of the Nigerian Economy, Various Issues (FOS, 1999)

Smallholder farmers constitute most of Nigeria's farm holdings. Between 1973 and 1974, the number of farm holdings in Nigeria was 29.808 million (Olayide et al., 1980). It is estimated that this has increased to 48.113 million in 2004 (CBN, 2005; World Bank and FAO, 2008; World Bank, 2008c). In 2006, the size-distribution of land holdings in Nigeria was thus: (1) Small: 0.10 - 5.99ha (84.49 per cent) (2) Medium: 6.0-9.99ha (11.28 per cent) and (3) large: above 10ha (4.23 per cent) (NBS, 2006). If all farms below 10ha are considered small according to international standard, then more than 90per cent (or a total of 48.113 million holdings) of all farm holdings in Nigeria as at 2004 would be classified as small (Apata et al., 2009).

Thus, Nigerian agriculture is characterized mainly by farming families who own and cultivate small plots of land (generally between 0.2ha to 2ha depending on choice of crop and ecological zones) using traditional methods of cultivation(NBS, 2005). Labour on these farms is mostly planned around the family but so also are land and capital(Olayemi, 1982; Olayide, 1982). Energy input is generally low as farmers rely more on simple tools and technologies. The cropping system is generally mixed per plot and the choice of crops is dependent on several factors like season, profitability, availability and resilience (Osemeobo, 1992). Whereas resource use is efficient within the framework of the land tenure systems (Olayide, 1982), output is usually low (Olayemi, 1982) as growth in food production is mainly dependent on increasing the crop area cultivated (FMA, 1984; Osemeobo, 1987). According to Osemeobo (1992), "the traditional production system was originally well conceived by the smallholder, [but] it fails to meet food requirements for the growing population [because]...smallholder farmers...operate in the midst of famine and mounting food deficits, and theyare unfortunately deprived of the basic essentials of life: health care, good water supply, education and good roads" (pp. 102). Yet, smallholder agriculture remains a significant food provider for majority of Nigerians and contributor to agricultural exports (Ikpi, 1995; Oyeranti and Olayiwola, 2005).

The poor performance of Nigerian agriculture directly impacts on economic development and growth as well as poverty. The "Poverty Profile for Nigeria 1980-1996" indicates that poverty (the number of people living on less than 1 USD per day) is on the increase. In 1996 about 67 million

people are poor representing more than 65 per cent of the population. The incidence of poverty is higher in rural areas where the people are primarily engaged in smallholder agriculture (table 3)(World Bank, 1996; Canagarajah et al., 1997; Aigbokhan, 1998; FOS, 1999; Ogwumike, 1998; Okojie et al., 2000; Apata et al., 2009). The Northern part of Nigeria (where this study is situated) has the highest percentage of poverty (NBS, 2005).

Year	Urban	Rural
1980	17.2	28.3
1985	37.8	51.4
1992	37.5	46.0
1996	58.2	69.8

Table 3: Poverty trends in Nigeria by sector (%) 1980-1996
Source: (Ogunlela and Ogunlela, 2008)

The sharp rise in poverty in Nigeria is said to be the result of critical but related factors which include rapid population growth (table 4), low growth of the economy, prevalence of inappropriate resource allocation, low investment rate, geophysical limitations, narrow production base (Ogunlela and Ogunlela, 2008). Poverty is said to also cause or aggravate food insecurity in Nigeria. Others are lack of consistent access to good nutrition, poor food production, the unavailability of resources and coping strategies (Rosegrant et al., 2005).

Annual Growth %	1991-2000	2000-2010	2010-2025	2025
	2.83	2.80	2.75	2.70
Population (in Million)	1991	2000	2010	2025
	88.517	113.790	145.896	219.165

Table 4: Present and Future Population Project
Source: (JICA, 1995)

Environmental degradation is also closely related to poverty in Nigeria. Nigerian smallholders are continuously working in a changing and challenging environment. Smallholder productivity is severely limited by natural and human-induced problems such as, climate change (e.g. changing rainfall patterns), loss of biodiversity, air and water pollution, pollution attendant to oil and gas exploitation, drought and deforestation, flooding, coastal and gully erosion, land degradation, deforestation, over-grazing and other socio-cultural problems. The economic implications of land degradation for farmers include low income and increased risks for poor households (Barbier, 1998). Conversely, poverty influences the process of land degradation as poor households are not always enthusiastic to control land degradation since their economic livelihoods are directly

dependent on the exploitation of lands that are highly vulnerable to degradation (Ogunlela and Ogunlela, 2008).

Previous attempts at poverty alleviation in Nigeria were centred on growth, basic needs and rural development approaches. Before the 1980s, the government was indirectly involved in poverty reduction. National development plans were established to foster growth. Some of the programmes under these plans included: the River Basin Development Authorities (RBDA), the Agricultural Development Programmes (ADP), the Agricultural Credit Guarantee Scheme (ACGS), the Rural Electrification Scheme (RES), the Rural Banking Programme (RBP), Operation Feed the Nation (OFN), Free and Compulsory primary Education (FCPE), and the Green Revolution (GR). Some of them had positive effects on poverty reduction but could not be sustained (Ogwumike, 2003).

In the Structural Adjustment Programme (SAP) era, government was more directly involved in poverty alleviation through the following programmes: Directorate for Food, Roads and Rural Infrastructures (DFRRI), National Directorate of Employment (NDE), Better Life Programme (BLP), Better Life Programme (BLP), Family Support Programme (FSP) and Family Economic Advancement Programme (FEAP). Many of these programmes failed to significantly reduce poverty and implementation of SAP sometimes worsened poverty (Oladeji and G., 1998). Since 1999, the government has renewed its commitment to poverty reduction through programmes such as Poverty Alleviation Programme (PAP) and Poverty Reduction Strategy Papers (PRSPs) under the National Economic Empowerment Development Strategy (NEEDS).

2.3 Agricultural Growth, Smallholders and Sustainability in Nigeria (1960-2000)

Since independence in 1960, Nigeria has introduced a host of policies and programmes aimed at improving agriculture. Manyong et al.(2005) and Daramola et al.(2007) identify four distinct policy phases in the evolution of agricultural support in Nigeria: (1) 1960-1969, (2) pre-structural adjustment (1970-1979), (3) the structural adjustment period (1980-1989), and (4) the post-structural adjustment period (1990-to date). These different phases and policies were guided by distinct philosophical positions on what the role of governments should be in development, especially agricultural development. In some instances, the government was directly involved as the key agent of development while at some other times it distanced itself from development. Often, multilateral and lending institutions were influential in what position the government took. Also, support for agricultural producers “shifted significantly over time, with agricultural producer support first declining after the country’s independence, then increasing again between the mid-

1970s and the mid-1980s, and afterwards moving towards an incentive-neutral stance” (Walkenhorst, 2007, p. 2).

Between 1960 and 1969, agricultural development was heavily decentralized. The government adopted the philosophy of economic *laissez faire* and was only minimally involved in agricultural intervention. Private sector participation was emphasized while the government took the back seat and sometimes acted as an arbiter in the development process. Smallholders were encouraged to produce both food and cash crops through cooperatives and farm settlements which provided the link between the government and farmers and helped in the supply and distribution of farm inputs as well as in marketing cash crops (Osemeobo, 1992).

However, this decentralised approach to agricultural production did not significantly improve agriculture. There was an increase in food supply short-falls and retail food prices, decline in foreign exchange, fall in agricultural share in GDP and rise in import value of food and live domestic animals (Osemeobo, 1992). With regards smallholders, government’s position was not always favourable due to the emphasis on the private sector whose goal was agricultural expansion and cash crop production. Government support to smallholder farmers was negligible and took the form of agricultural research and extension, export crop marketing, and pricing activities. The environmental impacts of agricultural policies between 1960 and 1969 were mixed. Most of the production was based on simple techniques. Nonetheless, there was increased deforestation of the rainforests for cash crop production. The impact on the soil was however, mitigated by tree crops (cocoa, oil palm and rubber). Other environmental consequences include reduced biodiversity of the tropical ecosystem, loss of wildlife habitats and indigenous plants, overexploitation of land resources in the savannah zones due to intensified production and forced production based on chemical fertilizers (Osemeobo, 1992, pp. 103).

Between 1970 and 1979, there was increased government involvement in agriculture which saw a proliferation of major programmes and institutions aimed at increasing agricultural production in Nigeria by means of technology improvement and infrastructure development through large-scale agricultural projects (Davis, 1987, p. 127). Some of the policies pursued by different governments in this phase included a strengthening of agricultural sectors and institutions so as to promote agricultural marketing, cutting cost of agricultural production and boosting agricultural product prices. Policy instruments introduced included the agricultural marketing and pricing policy aimed at regulating the price of commodities like cocoa, groundnut, palm produce, cotton, food grains and rubber. Six commodity boards were established in 1977 to this effect.

The government also vigorously pursued a policy of input supply and distribution of modern inputs like fertilizers and agrochemicals, seed, machinery and equipment and so on. In addition to this, agricultural inputs like fertilizer, seeds, and tractor hire services were heavily subsidized. Through the agricultural mechanization policy, tractor hire services were introduced at the state level, import policy with regard to tractors and agricultural equipment was liberalized and massive assistance was given to 'big' farmers by government for the purchase of farm equipment and machinery. To supplement this, the government also encouraged the establishment of agricultural cooperatives by which means rural people will be organized for effective farm input distribution.

In line with government's emphasis on agricultural commercialization of cash crops (United Nations, 1997), the National Seed Service (NSS) was created in 1972 to produce and multiply improved seeds of rice, maize, cowpea, millet, sorghum, and wheat and to multiply cassava. Under this programme, foundation seeds were to be produced by the project to Research Institutes, seeds were to be tested and certified by The Seed Certification and Quality Control Programme and seed testing laboratories and processing plants were to be introduced or rehabilitated. There was also an attempt to create awareness and disseminate information about 'modern' seed varieties. Despite this, the initial uptake of foundation seeds by farmers was very low (United Nations, 1992).

The government also put in place a water and irrigation policy aimed at developing and expanding the country's land and water resources. The River Basin Authority Programme (RBDA) was established between 1970-74 and charged with the multiple tasks of undertaking a comprehensive development of both surface and underground water resources for multi-purpose use; providing water reservoirs and lakes for the purpose of farmers and recognized associations; controlling pollution in rivers, lakes, lagoons and creeks; developing fishes and improving navigation of rivers, lakes, reservoirs, lagoons and creeks; mechanical clearing and cultivation of land for the production of crops and livestock, etc.; and large-scale multiplication of improved seeds, livestock and tree seedlings for distribution to farmers and for afforestation schemes (Akindele and Adebo, 2004). Generally, government's policy on irrigation was geared towards modernization and large-scale dam construction, programmes that inevitably failed to result in the desired goal of increased productivity among smallholders.

Institutional provisions during this period targeted the supply of credit, technology improvement and transfer, seed improvement and supply, agricultural research and mechanization and commodity marketing and pricing. Institutions like the Agricultural Research Council of Nigeria, the National Science and Technology Development Agency and the Centre for Agricultural Mechanization were created to pursue agricultural research and development.

In the area of extension, the focus was on specific national programmes and projects as against the old state-based models. The National Accelerated Food Production Project was launched in 1972 and the Rural Integrated Agricultural Development Programme (ADP) launched in 1975 to reach farmers and promote the adoption of new technologies. The ADPs (mainly with World Bank funding) were Nigeria's first major practical demonstration of the integrated approach to agricultural development.

The government also created a legal framework to promote agricultural development. Such decrees as the Nigerian enterprises promotion decrees of 1972 and 1977 were meant to indigenize certain enterprises and encourage participation by Nigerian investors. Some enterprises were reserved exclusively for Nigerians whereas some were kept open for joint participation by Nigerian and non-Nigerian investors. The Land Use Decree of 1978 was enacted which imposes for the first time in Nigeria uniform system of land titles and land control. Under this decree, the 'rights of occupancy replaced all previous forms of title and became the basis upon which land was to be held.

In addition to the legal framework, macroeconomic policies that include fiscal, monetary and trade policies were introduced to facilitate agricultural development. Generally, investment in export-agriculture was supported and more credit was directed at the agricultural sector. Through the abolition of export duties on scheduled export crops, agricultural export was promoted.

Some of the major institutional programmes that characterized the pre-structural era were the Operation Feed the Nation (OFN) and the Green Revolution. Launched in 1976, the OFN was aimed at increasing productivity through the adoption of new technological packages. The media was heavily involved in this campaign to get farmers to adopt improved seeds, use fertilizers and other agrochemicals. Despite this effort at boosting agricultural production and increasing food access, OFN failed to meet its target as more food continued to be imported while cash crop export also declined.

In response to the failures of the OFN, the Nigerian government launched the Green Revolution (GR) in 1979 with the major task of curtailing food importation through improved crop and fibre objectives (Emenyeonu, 1987, p. 109). Through the promotion and adoption of very specific technology, it was expected that farmers would increase food production per unit of land and labour. Yet, despite the huge amount of money invested in the GR, it was not very successful for a number of reasons. A number of reasons have been identified for this failure: Firstly, it did not take into account the existing agricultural systems, especially among Nigerian smallholders. The

GR did not take into adequate account the needs of smallholders and expected that they would systematically discard their old and time tested patterns of farming for novel ones. Secondly, the prevailing tense political climate and flawed system of input distribution hindered its efficiency. In the end, GR failed to produce enough food to meet the needs of the nation and Nigeria's import bill continued to rise. Thus, Nigeria spent over NGN5.5 billion on food importation between April-December 1983 (Emenyeonu, 1987).

In general, the performance of agriculture in Nigeria between 1970 and 1979 was equally poor and policies and programmes failed to increase agricultural production. There were widening food supply gaps, rise in retail food prices, rise in food imports, fall in GDP, decline in labour force and high overhead cost (Osemeola, 1992). This poor performance has been blamed on three factors: the civil war (1967-1970) which reduced agricultural production, poor and inadequate funding, and crop loss due to drought between 1972 and 1974 (Ibid.). Environmental consequences included an increase in area of cultivated land through mechanized farming and irrigation schemes and deforestation, "impounding of water sources with drastic impact on biotic resources," fall in water tables, desertification in arid areas and flooding in lowland areas due to an increase in areas of dry land, degraded marginal lands and reduced biodiversity (Osemeola, 1992, pp. 103).

The third phase of Nigeria's agricultural development coincided with the introduction of the structural adjustment sponsored by the International Monetary Fund and the World Bank. It was meant to restructure the country's faltering economy, a problem exacerbated by increased debt and falling oil price. Among other things, the structural adjustment programme was meant to diversify Nigeria's economic base and reduce Nigeria's dependence on oil exports and commodity imports. It was also meant to rationalize the consumption patterns of the people and the country's monetary and fiscal policies. Hence, SAP was geared towards achieving fiscal and balance payments viability and increased non-inflationary economic growth. Another of its objective was to ensure food and raw-material self-sufficiency. As a matter of fact, Manyong et al.(2005) claim that agriculture was the cornerstone of the structural adjustment programme on which it relied to achieve its objectives.

Some of the key policies designed to achieve these objectives included the strengthening of demand management policies, a broadening of domestic production and supply base of the economy, ensuring realistic exchange rate and efficient resource allocation through the Second-Tier Foreign Exchange Market (SFEM), restructuring of tariffs so as to aid industrial diversification, abolishment of price, trade and exchange control and commodity boards, decontrol of interest rates and restructuring of the public sector (NCEMA, 2004; Manyong et al., 2005). Through

liberalization, therefore, the private sector was given a more prominent role in the domestic economy.

Evaluating the benefits of SAP especially on the rural sector in Nigeria is not easy due to the absence of reliable data on various sectors of the economy. Similarly, there is no adequate basis for evaluating the macroeconomic policies and political impact of SAP and other SAP induced developments such as land acquisition for large scale farming (Egwu, 1998). That notwithstanding, some have argued that SAP had certain positive impact on some aspects of the Nigerian economy. For instance, some have argued that through favourable policies like the devaluation of Naira, the dismantling of market boards and some of the special incentives given to farmers, SAP helped to improve the prices of agricultural goods and spill-over effects especially of traditional export crops (Ihimodu, 1993; Onokerhoraye, 1995). This development, claimed certain analysts, increased the competitiveness of farmers in both the product and factor markets and producers enjoyed benefits such as prompt and/or pre-payment in the form of credit advances (Olomola, 2006).

However, some analysts have argued that Nigerian smallholders and rural dwellers did not benefit from the market-based adjustment programmes (Stewart, 1991; Ihonvbere, 1993; Lewis and Stein, 1997). Instead of solving the problem of agricultural productivity, it plunged more people into poverty and hunger. On the contrary, it was the rich farmers who benefited from the liberalization of agriculture. For instance, the removal of subsidies on inputs like fertilizer made the prices too high for smallholders. In addition, the intensification of land grabbing affected smallholders in significant ways. As a result of the rising cost of traded goods, several smallholders were forced to rent their land partially or fully while others fell back on lineage system as a cushioning mechanism. Inflation as a result of devaluation furthermore eroded the purchasing power of poor rural dwellers (Egwu, 1998). Furthermore, agricultural policies under SAP were said to have put additional pressure on the natural environment due to the demand to increase output. Government's distance from business enterprises meant less attention was paid to social benefits as emphasis on private economic costs and benefits led to excessive exploitation of the environment (Titilola, 2000).

In general, agricultural policies between 1980 and 1989 did not achieve the agricultural development hoped for and Nigeria evolved from a net-exporter of agricultural crops to a large-scale importer of agricultural and food products. When revenues from oil exports plummeted and government debts surged, the high fiscal spending and excessive state control became unsustainable in the early 1980s (Walkenhorst, 2007). Efforts at encouraging smallholders to increase their productivity through use of increased yield and extensive cultivation of land failed to boost agriculture. Also, the new operational strategies and programmes for credit, modern inputs

and infrastructural facilities (e.g. the Directorate for Food, Roads and Rural Infrastructure (DFFRI)) did not deliver as expected. Hence, the GDP as well as export earnings declined, domestic food supply fell while domestic food prices increased. Due to the emphasis on intensive production through modern technologies and intensive use of chemicals and monoculture production, the environmental impacts of policies and programmes include “outbreaks of pests and diseases respectively by quail birds on grains and virulent bacteria and fungal problems on cassava, rice, millet, maize, beans and yam; breakdown of resistance on hybrid maize and other crops which were supposedly resistant; abuse and misuse of fertiliser usage leading to soil pollution in some sensitive ecosystems (Osemeola, 1992, pp. 103).

In recent years (the post-structural era – since 1990), the Nigerian government has re-launched its interest in the agricultural sector and has formulated a number of policies and programmes to resuscitate the sector. Some of the programmes include the National Acceleration Crops Production Programme (NAICPP) - 1996; the Agricultural and Rural Transformation Programme (ARTP) – 2000 and the National Economic Empowerment Development Strategy (NEEDS) which was introduced in 2003/2004 as a reform programme that encourages private sector operations. The NEEDS initiative includes programmes such as the Presidential Initiative Programmes (for instance, Presidential Initiative on Rice Production, Processing and Export, Presidential Initiative on the Development of Vegetable Oil, and the Presidential Initiative on Cassava Production and Export). Moreover, in 2005, Nigeria adopted the ECOWAS common external tariff, which involved substantial reduction in import duties and greater regional participation in areas like phasing out special tariffs on sensitive products and quantitative import restrictions by 2007 (Walkenhorst, 2007).

NEEDS is Nigeria's Poverty Reduction Strategy Paper (PRSP) prepared in broad consultation with development partners and donors (the IMF and the WB) and it describes Nigeria's macroeconomic, structural, and social policies in support of growth and poverty reduction. PRSP have become integral to development planning process in Africa and provide a framework for achieving the Millennium Development Goals (MDGs). The PRSP is based on the following core principles: country-driven, result-oriented, comprehensive in scope (recognizes multidimensional nature of poverty - conflict issues, indigenous people, human rights, HIV/AIDS), partnership oriented (donors, civil society, government, private sector), long-term in perspective and participatory (World Bank, 2002). The objective of PRSP is to achieve a strategy that is locally generated and owned and developed through wide participatory dialogue at both the micro and macro policy making levels, thus making the poor participants in the

development process rather than passive recipients. It aims to encourage government accountability to the people and not to external donors. In general, PRSP has challenged the Nigerian government to make growth strategies pro-poor.

Under the new Nigerian agricultural policy, the government has assumed more control over policy implementation through reform of the non-fuel export subsidy regime that has been undermined by bureaucratic inefficiency. The new agricultural policy has the following broad policy objectives: ensuring self-sufficiency in basic food commodities and food security; increasing the production of agricultural raw materials for industries; increased production and processing of export crops, using improved production and processing technologies; generating gainful employment; rational utilization of agricultural resources; improved protection of agricultural land resources from drought, desert encroachment, soil erosion and flood; and the general preservation of the environment for the sustainability of agricultural production; promotion of the increased application of modern technology to agricultural production and improvement in the quality of life of rural dwellers (NPC, 2004). The government claims that this effort has already yielded some positive results with the agricultural sector sustaining the 7 per cent growth rate attained in 2003/2004 (ICAARD, 2006).

A number of National Special Programmes for Food Security (NSPFS) have also been implemented in different parts of the country under the new Nigerian agricultural policy initiative. The aim of the NSPFS is to attain food security, generate employment, reduce rural poverty through the dissemination of improved technology, strengthen research and extension, utilize water and land effectively for increased production, promote and develop aquaculture and small ruminants, and finally manage post-harvest losses (ICAARD, 2006). The Second National *Fadama* Development Project (NFDP-II) was launched under this initiative and its main thrust is to improve the productivity and income of *fadama* (floodplain users) (ICAARD, 2006).

2.4 Explaining the Slow Growth in Nigerian Agriculture

Several reasons have been identified for the general failure of agricultural support programmes and policies in Nigeria. These include physical and social factors: challenging environment, environmental degradation, and insufficient inputs and assistance to farmers. However, agricultural policies have been identified as the principal cause of Nigeria's poor agricultural performance. On the whole, there has not been policy stability in Nigeria as policies were experimented with and discarded in quick succession (Walkenhorst, 2007). Thus, the agricultural sector was largely characterized by the combination of half-hearted strategies, reversals, contradictions, or at best, misguided interventions (Bogoro, 1999). For instance, between 1986 and 1994, rice imports were

illegal. In 1995, imports were allowed at 100 per cent tariff. In 1996, the tariff was reduced to 50 per cent and became full cycle to 100 per cent in 2002 and partially in 2008 (Babaleye, 2008). Another major constraint to the effectiveness of past agricultural policies is the fact that many of the institutions charged with coordinating and implementing these programmes were weak and often overtly bureaucratic. There was also duplication of institutional arrangements for policy and program coordination as well as inefficient resource use among different agencies of government (Walkenhorst, 2007).

However, some have argued that the problem is with the agricultural models and systems themselves. All too often, the problem of agriculture and agricultural productivity in Nigeria and indeed most of Africa has been reduced to insufficient mechanization, low inputs (such as fertilizer, herbicides, insecticides and high yielding seeds and so on) and inadequate irrigation. Such a technical and production-function model identified the solutions as: increased provision and availability of subsidized fertilizer and other chemicals, more improved seed varieties, bigger dams for irrigation, and expanded microcredit (Eicher, 2003b; IAC, 2004). The emphasis is on technical interventions, the ideals of expert knowledge and the desire to replicate Asian Green Revolution (Cowan and Shenton, 1996). The focus on 'agribusiness' for cash crop production not only affects food production but also results in severe environmental damage (Oculi, 1979; Lawal, 1997; Osemeobo, 1992; Ogen, 2003). Whereas in some cases, increasing technical assistance has resulted in increased output, the production-function model has been questioned because it glosses over the unique social and biophysical problems that smallholders face (Meinzen-Dick et al., 2004). Also, it often ignores the needs of small farmers and their traditional knowledge systems which are regarded as inferior. Lack of institutional recognition has seriously compromised and in some cases destroyed the sustainable farming practices of many smallholders.

Many have argued that the new agricultural and economic policy initiatives show no significant departure from their predecessors in that they fail to adequately take into account the role of Nigeria's smallholders and indigenous knowledge systems in achieving food security. They are targeted at commercial farmers and centre on input-supply as a requirement for increased productivity (Tharakan and MacDonald, 2004). Also, some have cast doubts on the potential of the new strategy to effectively improve production. Furthermore, NEEDS and PRSP⁴ face significant

⁴On a wider scale, PRSP has been criticized for being a disguised perpetuation of old WB thinking and policy prescriptions. Some have questioned the ability of longstanding growth model and policies to really reduce poverty, stressing that growth alone does not address broader issues of inequality and the growing divide between the rich and the poor. Also, it is said to exclude non neo-liberal parameters (such as land and agrarian reform, progressive taxation, support for domestic markets and protection, food sovereignty and the protection of the environment) essential in poverty reduction. Additionally, national ownership of PRSP as well as genuine participation and ownership by the poor are said to be limited by external control at different stages of implementation (Guttal et al., 2001).

challenges which include: weak macroeconomic framework, ensuring the integration of cross-cutting issues, significant variation in the depth of participation in the PRSP process, problems of ownership, alignment and harmonization of donor assistance and externally imposed conditionality (UNECA, 2006). An important criticism of PRSPs in Nigeria and other developing countries is the failure to adequately account for the role of resource access and environmental management in the lives of the poor and their potential contribution to poverty reduction programmes. Several studies (including in Nigeria) have assessed the extent to which PRSPs integrate poverty-environment relationships in general or in specific sectors (e.g. forestry, biodiversity and water) and concluded that these issues were inadequately and inconsistently incorporated in PRSPs (Boj and Reddy, 2003b; Boj and Reddy, 2003a; Oksanen and Mersmann, 2003; Bindraban et al., 2004; Boj et al., 2004; Slaymaker and Newborne, 2004). For instance, the initial draft of NEEDS completely ignored environmental concerns and only incorporated them as an afterthought (Oladipo, 2004). Several studies have shown that inclusion of environmental issues in PRSPs of many countries was sometimes driven by donor concerns and not necessarily domestic political priorities (ODI and DfID, 2002). A related criticism of PRSPs is its failure “to assess the potential impacts of proposed growth policies on environmental sustainability, maintenance of critical ecosystem functioning, and key natural resources relied on by the poor for their livelihoods” (Oksanen and Mersmann, 2003, p. 137). Thus, PRSPs frequently propose incentives to encourage high-input, export-oriented agriculture to stimulate economic growth, yet rarely do they analyse the risks of this approach which harms small-scale rural farmers and weakens their ability to manage local natural resources” (Tharakan and MacDonald, 2004, p. 25).

Generally, alternative agriculture is viewed with suspicion in Nigeria and consideration of environmental sustainability scarcely informs policy decisions. Also, many programmes continue to neglect traditional systems and smallholders and thus fail to benefit from the diverse and rich traditional systems that abound in Nigeria. Institutional support for smallholder farmers has been limited or non-existent as the Nigerian government has consistently pursued an approach to agriculture based on dominant technological models which are limited even in their technological horizon and ignore sustainable and productive practices such as crop and livestock integration (Scoones and Wolmer, 2002).

2.5 Nigerian Agriculture and the Petro-Dollar Paradox

In order to understand the problem in Nigeria’s agricultural sector, its link with other national sectors is essential. Despite its huge oil reserves and the status of petrol as its main foreign earner, Nigeria remains predominantly an agrarian country with agriculture providing the bulk of the

domestic food output and employing substantial percentage of the population. Yet, Nigeria's agricultural output falls abysmally short of the food needs of its population and hence has to rely on food imports. Nigeria continues to spend over \$350 million on rice importation alone annually.

Paradoxically, agriculture presents the greatest potential for combating hunger and poverty in Nigeria because it has the least demand for foreign exchange and hence it is cost effective with regards domestic resource utilization (fig 2). Yet, it was the oil boom (since the 70s and 80s) that heralded the collapse of the agricultural sector in Nigeria. Cheap and subsidized agricultural produce such as rice and maize grossly undermines the capacity of smallholders to produce more. Food importation policies killed research initiatives and farmers' enthusiasm to give national research breakthroughs a trial.

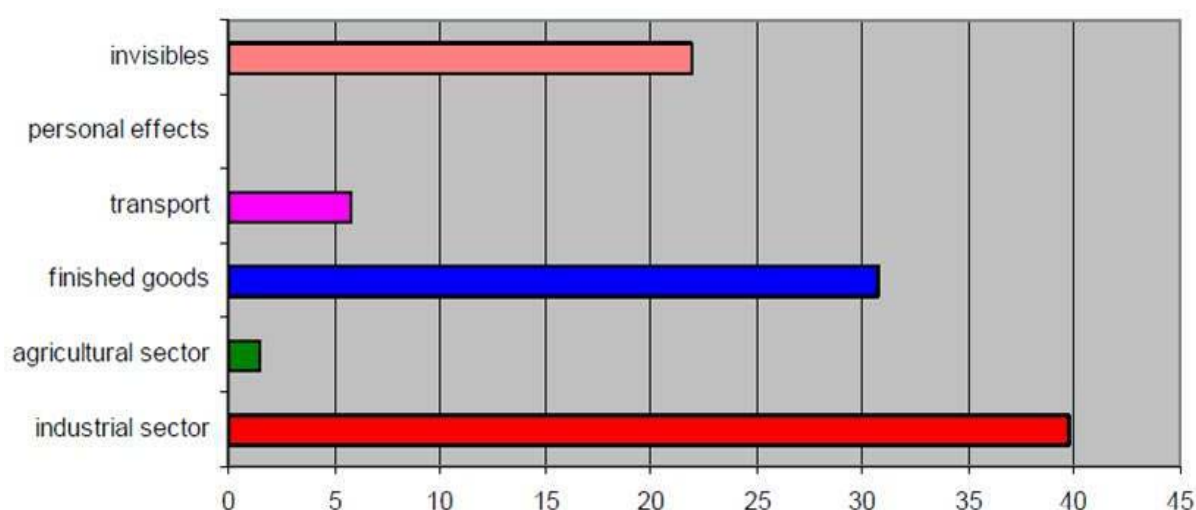


Figure 2: Average Sectoral Utilization (share in %) of Foreign Exchange (in US\$ million)
Source: (African Institute for Applied Economics, 2005)

Many experts explain Nigeria's profligacy and lack of will to vigorously resolve the problems of food security and poverty to the petro-dollar problem. Firstly, the Nigerian government spends so much money on food importation and totally removes duties and taxes on all imported grains (as they did in the height of the food crisis) simply because the money is there to spend (Aderinokun, 2008). For instance, between 1999-2007, the Olusegun Obasanjo administration spent over NGN300 billion on fertilizer importation without any significant change in agricultural output of smallholders for whom the fertilizer was intended (Shaibu and Uja, 2008). The Nigerian Agricultural Cooperative and Rural Development Bank (NARCDDB) alone claims to have invested NGN29 billion in over 500,000 agricultural projects across Nigeria in the past seven years (Azubuike, 2008). Similarly, in the 2008 farming season, the Nigerian government procured 650,000 tonnes of fertilizer. Yet, the true beneficiaries of government subsidy on all farming inputs and at all levels are not genuine farmers but corrupt government officials and their contractor allies.

Secondly, petro-dollar has made agriculture the poor man's enterprise as many young people migrate to the cities in search of better job opportunities in the oil and affiliated sectors of the economy. In fact, the percentage of Nigerian students enrolling for courses like petrochemical engineering is on the rise while those in agriculture and related fields continue to plummet. Finally, the huge earnings from petrol make Nigeria strictly a consumer society and aggravate the propensity for emergency measures instead of real solutions to the substantial problem of hunger and poverty that confronts that country. The government generally lacks commitment to planning, organizing and coordinating of the agricultural sector.

Paradoxically, Nigeria has never been better placed to solve the problems of hunger and poverty than in the last two decades. The huge earnings from petro-dollars could be used to fund agricultural research and extension targeted at improving the farming systems and practices of smallholders, reducing the drudgery associated with it and giving the farmers enough incentives to produce more. Similarly puzzling is Nigeria's inability to exploit its oil wealth to develop a viable mechanized and large-scale agribusiness sector. Except for isolated mega farms owned by very rich Nigerians, the bulk of the food in the country is still produced by smallholders. Most farm inputs (machinery and agrochemicals) are still largely imported despite the huge potential of the Nigerian petrochemical industry. This has basically been due to structural inefficiency and is symptomatic of the consumer nature of Nigeria's elite and the country's reliance on cheap and easily accessible imported goods.

2.6 *Fadama* (Floodplains) Systems: Geography, Ecology and Importance

For centuries, smallholders have utilized irrigable land/floodplains and low lying areas underlined by shallow aquifers found along Nigeria's river system for the cultivation of basic food crops, like vegetables, particularly in the dry season. There are almost 3,000,000 ha of such fertile soils with residual moisture in the dry-season which offer great opportunities for the arable farmers to grow off-season high value crops. Similarly, livestock keepers depend on the *fadama* areas for water access and dry season fodder. The *fadama* areas are also important inland fisheries areas.

Typically, floodplains are flat lands or regions which serve as floodways and are usually inundated by lateral overflow of water at some point of the year as a result of their proximity to a water body (stream or a river) (Junk et al., 1989). In several parts of the world, like the Nile Valley and Mesopotamia, natural floodplains were regarded as cradles of civilization and supported robust social-ecological systems (Sandberg, 1974). The transformation of these natural floodplains to controlled systems of irrigation for agricultural production within the framework of an equally complex socio-cultural and political milieu has been a subject of academic speculation (Wittfogel,

1957; Geertz, 1963; Boserup, 1965). Similarly, the rationale and processes behind such transformations have been scrutinised. Importantly though, many smallholders around the world have relied on small floodplains to harness water for farming and construct feasible ecological systems that were socially controlled (Sandberg, 2004). Water use and irrigation among these smallholders are often decentralized. The significance and advantage of this is that decentralization or participatory irrigation management increases the resilience of the system through effective water management as users are more involved in decision-making (Watanabe and Ogino, 2003).

Floodplains are an important source of groundwater and generally contain useful geological materials. They are able to hold excess water which are gradually released into the river system and seep into groundwater aquifers. Aquifers are porous and permeable body of unconsolidated sediments (sand or rock) through which water easily moves (fig 3). Generic aquifers have gradational boundaries into other aquifers forming an 'aquifer system.' Aquifers can be classified into 'confined' or 'unconfined.' Unconfined aquifers, also called water tables/phreatic aquifers typically do not have a confining layer (aquitard) between them and the surface water body from which they recharge. Confined aquifers typically have one or more aquitards between them and the surface (Johnston, 2008).

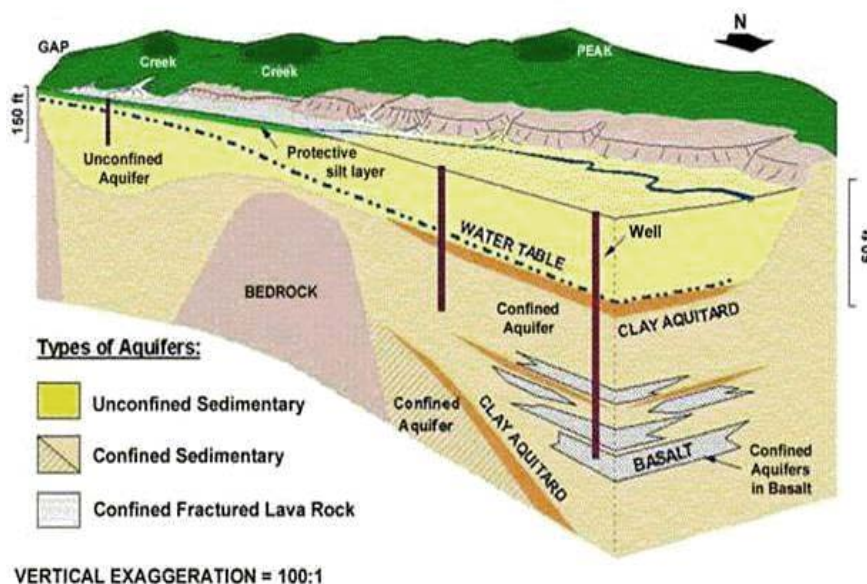


Figure 3: Anatomy of aquifers
Source: (Johnston, 2008)

Level of water in a given aquifer is not fixed as it varies from season to season. All aquifers have recharge and discharge zones from which they replenish or discharge. The major means of aquifer recharge is groundwater percolation of water (rainwater) which passes into the aquifer. This often happens slowly over long periods of time depending on aquifer permeability and its hydraulic

gradient. Discharge points for aquifers could be lakes or streams. Depending on depth, aquifers can be shallow or deep. Unconfined aquifers are often shallow and water can be extracted for agricultural purposes through the construction of shallow wells. This is possible because the groundwater in the underground aquifer is under pressure.

Aquifers are thus an important source of water for human activities such as agriculture and water supply. In many communities (North Africa, Middle East, US South West) shallow underground water has been exploited for irrigation and drinking purposes for centuries. In the US, for instance, groundwater withdrawal is significantly high and 2000 68% of fresh groundwater was used for irrigation and another 19% for public-supply purposes, such as drinking water (Ritter, 2006).

Due to intense engineering and regulation, however, natural floodplains in developed countries have been described as ‘functionally extinct’ (Graf, 1979; Graf, 1999; Knox, 2001; Tockner and Stanford, 2002; Woltemade, 1994). For instance, the floodplains of American Southwest have been considerably modified and eroded mainly through geomorphic modifications that have seriously undermined their sustainability (Doolittle, 2006).

2.6.1 Floodplain and Aquifer Vulnerability

Water aquifers can be polluted through contact with contaminated water sources, for instance through agrochemical use typical in industrial agriculture. Groundwater contamination can occur as a result of high soil hydraulic conductivity, high water-table conditions and high precipitation (Bosch et al., 1997). Several studies (in the US, Europe, India and Latin America, China) have demonstrated the effects of agricultural activities, such as fertilizer and pesticide use on groundwater quality through diffusion (Agrawal, 1999; Li and Zhang, 1999; Paralta et al., 2007). In the main, aquifers are delicate and any activity that affects the movement of water from the surface to the water table can potentially impact on the quality of aquifers (fig 4).

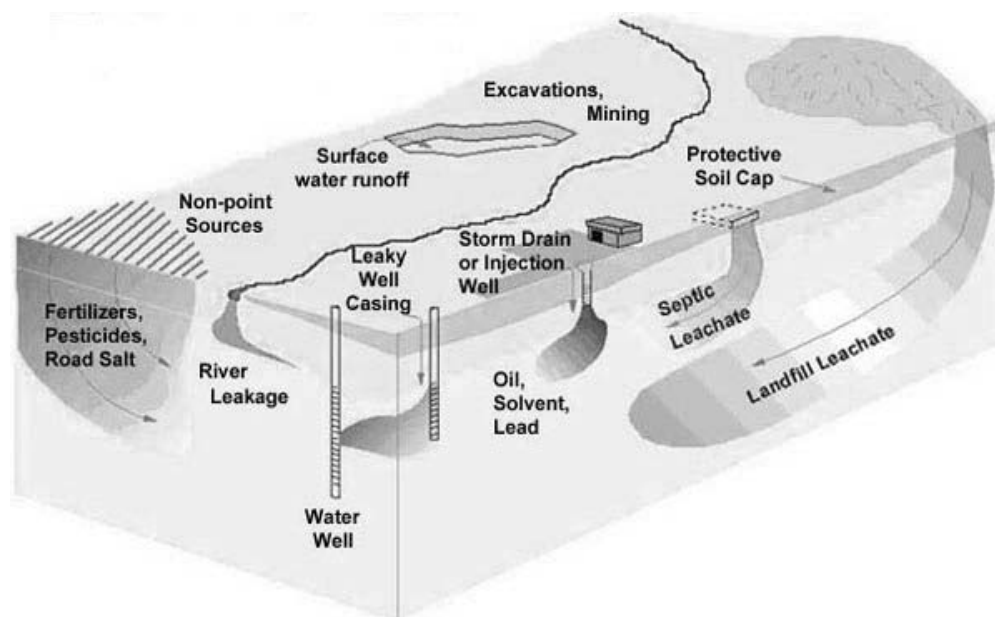


Figure 4: Common sources of underground water contamination
Source: (Johnston, 2008)

The effects of agrochemicals on the floodplains in Northern Nigeria and certainly in most parts of have not been adequately studied and neither have their health effects been properly understood. A number of reasons account for this. Firstly, in the case of health effects, a lot of the cases are not reported. Secondly, there are few analytical laboratories to carry out these analyses and the costs are usually high. Also, there is an absence of appropriate indicators for measuring the health of floodplains or their susceptibility to say agrochemicals. Equally absent is the enabling policy framework to guide research, management and development of African floodplains.

As already mentioned, agricultural sustainability in Nigeria is generally not given adequate consideration in policy planning as the overriding emphasis is improved production and higher yield through increased inputs. This problem is equally exacerbated by the failure of the local elite to promote indigenous knowledge systems and traditional food systems. Much of the present agricultural development scheme does not represent a gain on previous ones with regard sustainability. There is hardly a conscious effort to promote and maintain sustainable use of natural resources. Similarly, there is little emphasis on the importance of indigenous knowledge in managing the environment and ensuring sustainability.

2.6.2 Floodplains and Agricultural Production: The Case of Northern Nigeria

Floodplains are vibrant systems and important environmental unit supporting rich and diverse ecological activities making them important sources of biodiversity (Bayley, 1995). They are also an important source of soil nutrients and hence viable for agricultural purposes, especially in developing countries where people live very close to floodplain ecosystems (Adams, 1992). For

instance, the floodplains of Bangladesh are among the richest freshwater fisheries in the world and support over 300 species of fish and shrimps making them an important resource base for rural dwellers (Minkin et al., 1997). Similarly, in Brazil, floodplains not only sustain rural livelihoods through fishing and agriculture, they also promote biodiversity (Bisby, 1995; Perrson, 1997; Lowe-McConnell, 1999; Jackson et al., 2001; Siqueira-Souza and Freitas, 2004).

In many parts of Africa, floodplains support agricultural activities such as recession farming, fishing, grazing and ecotourism. This is also the case in the savannah and arid/semi-arid areas like those of Northern Nigeria (Adams, 1993). For instance, the Rufiji River Floodplains in Tanzania continue to support teeming rural smallholders (approximately 150, 000 people) who have developed an elaborate, versatile and risk-minimizing farming systems in the area (Marsland, 1938; Sandberg, 1974; Havnevik, 1993). These systems were mostly based on traditional agricultural methods and indigenous knowledge systems and consisted of the following: shared knowledge of “diversity of flood heights and onset times in various fields; drainage and fertility properties of the various soils; place and timing of vermin attacks; the flood resistance properties of seed varieties, especially rice; traditional land tenure mechanisms” (Sandberg, 1974). Hence, floodplains have been used by smallholders in many parts of the world both as a system of knowledge and power as well as a source of livelihood.

However, the complete economic, social and ecological value of goods and services delivered by floodplains in many parts of Africa has yet to be valued completely contributing to their improper handling by governments and policy makers. In many developing countries, floodplains have been severely eroded and sometimes destroyed in the last decades as a result of attempts at modernization, such as the building of hydro-development projects. Such mega dam projects were aimed at power generation and sometimes agricultural expansion. The result of this shift from traditional cultivation to the intensification characteristic of economic profitability model has often been disastrous as stable floodplain ecosystems were destroyed or altered and the livelihoods of poor smallholders dependent on them destroyed (Goldsmith and Hildyard, 1984; Drijver and Marchand, 1985; Horowitz and Salem-Murdock, 1991; Rodríguez, 2003; Asah et al., 2008). Similarly, such expansions and modernizations have led to floodplain degradation and sometimes destruction of floodplain resources and habitats (Attwell, 1970; Sheppe, 1985; Hyslop, 1988; Dunham, 1994; Nilsson and Dynesius, 1994). Often, the socio-economic impacts of modernization on floodplains are felt over long periods of years/decades as a study in Northern Nigeria shows (Thomas and Adams, 1999).

In the savannah and arid/semi-arid areas of Northern-Nigerian (where rainfall is often low or erratic) (fig 5 & table 5), seasonally inundated lands (*fadama*) are an important source of agricultural production and have been utilized using traditional methods and indigenous knowledge of the ecosystem accumulated over centuries (Adams and Hughes, 1986). *Fadama* is used in thesis in a narrow way to refer to “actual water surfaces of the ponds and swamps left behind as the floodwaters retreat from the floodplains of the largest river (Reed et al., 1967) and not simply the seasonally flooded lands that tend to dry up after the rainy season. *Fadamas* are floodplains rich in alluvial deposits and resources that are washed from the valley sides. They are just one type of *fadama* flooded by over-bank flow from a river (Chang, 1968). According to Turner (1977), *fadamas* may sometimes be flooded by sheet-wash from surrounding upland. They may also be waterlogged but not flooded. Kolawole (1991) describes the main characteristics of hydromorphic *fadama* soils as: high water retention capacity, unique characteristic which makes them suited for dry-season farming and deep (usually over 150 cm) and poorly drained soils. Additionally, “the soils are usually grey or pale brown, and the texture of the upper horizons vary from clay to loamy sand, but is usually loam or sandy loam... there is usually an increase in clay content with depth and is usually clay or clay loam below 100 cm, although these vary remarkably”(pp.5). Based on these geomorphological and hydrological features, Turner (1977) classifies *fadamas* into three broad categories: *fadama* without stream channels, stream-side *fadamas* and floodplain *fadamas*. It is the floodplain *fadamas* that are under consideration in this study.

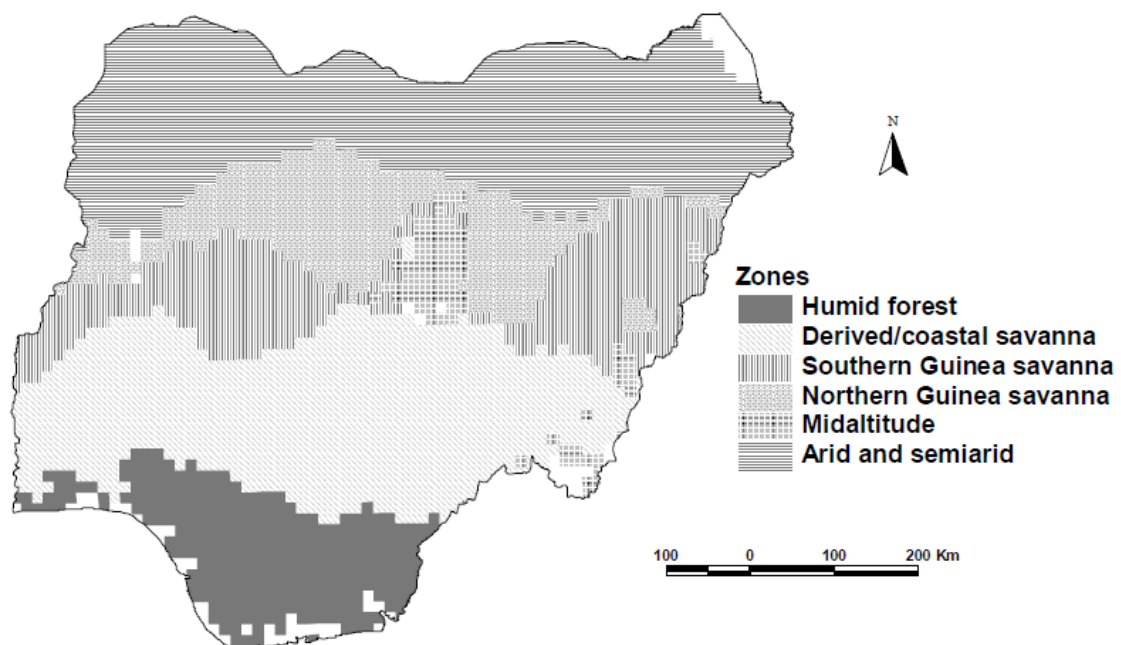


Figure 5: Agroecological zones of Nigeria
Source: (Salako, 2003)

Fadamas have been recognized since pre-colonial times for their value and highly developed agricultural and hydrological systems. *Fadama* agriculture underlines smallholder livelihoods in many parts of Northern Nigeria (the savannahs and arid/semi-arid regions) (Collins, 1923 ; Adams, 1986). Sustainable intensive farming has been observed in Kano since the 1800s (Clapperton, 1829, Barth, 1851) (Amerena, 1982). Traditional floodplain agriculture relied on the low lying aquifers of *fadama* lands to carry out agricultural activities both during the dry and rainy seasons. In the dry season, farmers cultivated such crops as vegetables, sugar cane and rice.

Zones description	% land	Annual rainfall	Monthly Temperature (°C)		
			Maximum	Normal	Minimum
Semi-arid	4	400-600	40	33-32	13
Dry sub-humid	27	600-1000	449	31-21	12
Sub-humid	26	1000-1300	37	30-23	14
Humid	21	1100-1400	37	30-26	18
Very humid	14	1120-2000	37	28-24	21
Ultra humid (flood)	2	2000+	33	28-25	23
Mountainous	4	1400-2000	32	29-14	5
Plateau	2	1400-1500	36	24-20	14

Table 5: Agro-ecological Zones of Nigeria with some Climatic Characteristics
Source:(FAO, 1991)(1991)

Writing on Northern Nigeria, Morel (1911) gave a succinct description of the resourcefulness, *knowledgeability* and dexterity of smallholder *fadama* users:

The fields themselves ... are protected from incursions of sheep and goats by tall, neat fencing of guinea-corn stalks, or reeds, kept in place by rope of uncommon strength... Equally astonishing are the irrigated farms... on the banks of water courses... plots marked out with... mathematical precision... divided by ridges with frequent gaps permitting of a free influx of water from the central channel, at the opening of which, fixed in a raised platform, a long pole, with a calabash tied on the end of it, is lowered into the water and its contents afterwards poured into the trench... Conditions... techniques... and industries displayed by the farmers of one district vary a good deal from the next. In the northern part of Zaria and Kano, the science of agriculture has attained remarkable development. There is little we can teach the Kano farmer. There is much we can learn from him. Rotation of crops and green manuring are thoroughly understood and I have frequently noticed in the neighbourhood of some villages small heaps of ashes and dry animal manure deposited along the crest of cultivated ridges... in fact, every scrap of fertilizing substance is husbanded by this expert and industrious agricultural people. Instead of wasting money... 'teaching modern methods' – a deluded notion – to northern Nigerian farmer, we should be better employed in endeavouring to find answers to the puzzling question of how it is that land which for centuries has been yielding enormous crops... can

continue doing so. What is wanted is an expert agriculturist who will start out not to teach but to learn; who will study for a period of, say, five years the highly complicated and scientific methods of native agriculture, and base possible improvements and suggestions, maybe for labour-saving appliances upon real.

In a chronicle of comments by observers (e.g. Lamb, 1913) who travelled through northern Nigeria in the 19th and early 20th centuries, Hill (1972) showed that *fadama* agriculture, such as the farming system of the Kano closed-settled zone, has been in existence for centuries. The system consists of well-kept plots of land, high frequency cultivation of plots, and the use of animal manure to fertilise the sandy soil. Despite structural changes and transformations in both production and trade in the 1960s and 1970s, Hill argues that these farming systems have not failed. Subsequent and recent studies have confirmed consistency in cropping intensity and livestock densities in the Kano closed-settled zone during the 1980s (Hendy, 1977; Bourn and Wint, 1994).

Even with the intensive nature of the farming system, a recent study concluded that it is “sustainable in an ecological sense in the short and medium term” (Mortimore et al., 1990). The soil study showed that over a period of 13 years, bulk density, particle size distribution, organic carbon, total nitrogen, pH, cation exchange capacity, and exchangeable potassium, calcium, magnesium and sodium remained stable. The reason for this is, concluded the study, the maintenance of soil fertility is done through well designed and time tested farming practices – and this is the prime objective of smallholder management (Mortimore et al., 1990). The management practices are based on availability of labour, livestock manure and fertilizer, and the choice of crop to be cultivated (Harris, 1996). The farming system is also flexible and farmers experiment with new crop cultivars alongside existing varieties, thereby “increasing the diversity of the genetic pool in their crop varieties and maximizing disease, pest and drought resistance” (Mortimore and Adams, 1997).

Two distinct zones of *fadama* areas existed before the advent of dams: “the zone of defined storm channels with low terraces with or without narrow floodplains [the Hadejia headstreams]...and the zone of extensive alluvial channel complexes [Hadejia and Yobe complexes]” (Olofin, 1993). Flooding was extensive and lasted longer in the second zone. *Fadama* agriculture depends on ‘natural recycling of nutrient through annual silt addition by flooding rivers’ (Olofin, 1993). The Sokoto floodplain, for instance, has been extensively studied to show how over 50,000 people depend on and utilize this important resource both for subsistence and local markets through the cultivation of such crops as cereals and a range of vegetables (especially in the dry season, i.e. recession

agriculture) (Adams, 1993; Kebbeh et al., 2003). Depending on the zone, water is managed either through the use of *shaduf* or the construction of terraces or a variety of valley bottom irrigation systems. Other activities engaged in by smallholders in this area include grazing and trading (Yahaya, 2002).

However, in the 1970s and 80s, under the influence of the FAO and spurred by the oil boom, the government embarked on the modernization of *fadama* areas. Over a period of two decades, the government spent more than US\$3 billion on irrigation schemes mainly through three different agencies: the Ministry of Agriculture and Natural Resources; Directorate of Foods, Roads and Rural Infrastructure (DFFRI) and; the River Basin Development Authorities (RBDA) (Pradhan, 1993). The government embarked on large-scale irrigation systems and the building of dams with the expectation that this would result in increased productivity of smallholders.

However, such large-scale hydro-agricultural projects as the Bakolori Irrigation Project in the Sokoto basin have largely resulted in disaster both for the smallholders and the floodplain ecosystem. Their failures represent the conflict of interest between local farmers and large agribusiness and construction companies contracted to build these dams (Beckman, 1984; Adams and Hughes, 1986; Kolawole, 1993). The impacts of the Bakolori Irrigation Project include alteration of water flow and hence farming practices of the smallholders and decrease in aquifer discharge due to increased evaporation which disrupted dry season farming (Adams, 1986).

The collapse of most of these large-scale irrigation projects in the floodplains of Northern-Nigeria (Bakolori, Goronyo and Wurno) left behind a number of environmental problems such as erosion, salinity and sodicity (Graham and Singh, 1997; Thomas and Adams, 1997; Barbier and Thompson, 1998; Graham, 2000; Graham et al., 2003). A study on groundwater quality in the Southwest Sokoto-Rima Basin in Northern Nigeria found the water to be slightly acidic with low to moderate salinity indicating low-sodium build-up but pointed to potential problems of water infiltration into the soils due to very low salinity levels. It also found a high incidence of nitrates (4.5 to >50mg.l⁻¹) due to high use of nitrogen fertilizers (Graham et al., 2006). In addition, large-scale irrigation systems destroyed cultivable *fadama* areas (Adams, 1985; Adeniyi, 1973; Nichol, 1991), eroded the sustainable and organically balanced agricultural systems of *fadamas* smallholders (Olofin, 1993) and resulted in increased rural-urban migration (Main, 1988; Olofin, 1991).

In face of the failure of large-scale irrigation projects in *fadama* areas, the government has reverted to small-scale irrigation practices with the hope of getting the farmers more involved. The *Fadama* Project (beginning in the late 80s) targeted smallholders who derive their livelihood from natural

resource exploitation in the *fadama* area. It was designed to be a participatory and socially inclusive approach that empowers *fadama* farmers, through the *Fadama* Community Association (FCAs) to take control of and manage their resources for their own development. The main financiers of the project are the WB, the African Development Bank and the Nigerian government. They provide funds for the provision of shallow tubewells in *fadama* lands for small scale irrigation, simplifying drilling technologies for shallow tubewells/ washbores; constructing *fadama* infrastructures; organizing *fadama* farmers for irrigation management, cost recovery and better access to credit marketing and other services; and providing vehicle, pumps and other equipment.

Other objectives of the *Fadama* Programme include: “improving mechanism for conflict resolution; supporting establishment of rural and non- farm enterprises; focusing on the contribution that can be made by women; and supporting improved management and increased food production and socially inclusive management of the resources in the *fadama* areas”(NFDO, 2005). It is expected that these measures will reduce the poverty level of these smallholder farmers through increased agricultural production and the attendant increase in income.

The *Fadama* Programme adopted a Community-Driven Development (CDD) in order to encourage extensive participation of the stakeholders at early stage of the project approval. Its main components include capacity building and advisory services, infrastructure development and project coordination and management. Some of the expected benefits for communities participating in the project include small scale infrastructure provisioning, acquisition of income generating assets for target communities, enhanced marketing techniques and practices, smooth project implementation, effective monitoring and evaluation systems (NFDO, 2005).

The *Fadama* Project is, therefore, meant to place in the hands of the communities the task of identifying, preparing and prioritizing of projects to be financed. These are then evaluated by the FCA to determine priority and practicability. NGOs and other groups are charged with monitoring this process. Target programmes to be funded include *fadama* road improvement, grazing reserves, service centres and market infrastructure, drainage boreholes, cold rooms, cooling sheds, rice processing and post-harvest equipment and maize processing into flour.

Some of the key achievements of the project are said to include: the introduction of Chinese type integrated production systems such as integrated rice-fish farming, poultry fish farming, integrated vegetable-livestock-fish production systems; post construction community based activities (erosion control, irrigation, tree/grass planting, fisheries etc.); introduction of new technologies to the Nigeria environment: walking tractors, high yielding rice varieties, utilization of neem seeds, food

processing (noodles, snacks etc.), fruit/vegetable preservation; introduction of all year round vegetable production; introduction of low cost technologies: e.g. poultry battery cages, production of green silage for dry season livestock feeding, day old chick/hatchable eggs production, etc.; assisting various *Fadama* Community Associations/groups to support community projects such as *fadama* access roads, markets stalls, processing equipment, water pump, tube wells/wash bores, boreholes, fishing equipment and advisory services and capacity building activities.

These notwithstanding, millions of smallholders are yet to be reached and the bureaucracy involved in getting funding is daunting. Also, because farmers are required to contribute a significant percentage of the total amount that they apply for, the project still favours wealthier rural dwellers. Similarly, in many communities the project is marred by corrupt practices of officials. Finally, research into indigenous knowledge systems and sustainable/affordable technologies is still underfunded.

CHAPTER 3

METHODOLOGY/METHODS

3.1 Research Framework and Philosophy of Research

3.1.1 Theoretical Perspective: Critical Realism

Realism is predicated on certain basic knowledge claims which include objectivity, fallibility, trans-phenomenality and counter-phenomenality (Collier, 1994, p. 6). By objectivity, realism maintains that the 'real' exists independent of our knowledge of it. In this respect, realists agree with positivists that what is applicable to the core sciences on causality, explanation and prediction are equally applicable to the social sciences. In fact, social science is an attempt to express in thought that which is 'real' in-itself and which acts independent of our thought (that is, the correspondence between the *transitive* objects of science and the *intransitive* objects of reality). Secondly, any claim that we make about what is real is not infallible but open to falsification - knowledge is not definitive or conclusive but open to refutation by further information. Thus even a scientific account of phenomena is deliberately partial. In addition, realists claim that knowledge is as much about underlying structures as about what is 'visible.' In fact, underlying structures are more enduring than the appearances they generate and they not only define and go beyond appearances; they actually can and do sometimes contradict appearances (Collier, 1994, p. 7).

Critical realism builds on the 'strong' realism outlined above. It starts by accepting the existence of the 'real' but moves beyond that towards something more fundamental in which the possibility of that which is actual is grounded. This is also called 'transcendental realism' and it is based on transcendental argument, i.e. what must be true for X to be possible? The emphasis in transcendental arguments is on uncovering 'structure that endures' as against simply 'a phenomenon that occurs' (Collier, 1994, p. 20). For critical realists, orthodox methodology suffers from 'epistemic fallacy' as it fails to maintain the distinction between ontology and epistemology which has resulted in the neglect of ontology. Critical realists believe that 'things' exist and are optimistic that we can know them.

3.1.2 Ontology of Research

Ontology seeks to answer the question, 'what is there to know?' and thus refers to the 'claims and assumptions that are made about the nature of social reality, claims about what exists, what it looks like, what units make it up and how these units interact with each other. In short, ontological

assumptions are concerned with what we believe constitutes social reality' (Blaikie, 2000, p. 8). For realists, social reality is stratified into three domains 'the real', 'the actual', and 'the empirical.' The empirical is that which can be perceived by the senses, i.e. experiences and events through observations, it is thus subject oriented. The 'actual' includes events, whether observed or not, which are logically prior to experiences. The 'real' includes processes, structures, powers and causal mechanisms that generate events, i.e. the 'power of things.' This power exists even when it is not causing events. The relationship between the levels can be explained as follows: the real is constituted by those mechanisms that generate the series of events that constitute the actual, whereas the empirical, in turn, consists of experiences of certain events. These layers of reality are interrelated, but not reducible to each other (Collier, 1994: 44).

Since the realist position is that there is reality out there independent of what we think of it, it makes a distinction between two objects of science: the 'transitive' and the 'intransitive' objects. Intransitive objects (structures and mechanisms) consist of the 'real' world independent of scientific inquiry. On the other hand, transitive objects are the scientific laws and theories that are designed to describe the intransitive (ibid., p. 51). These laws, therefore describe, the real essences of things that exist by necessity, such essences being their power or *tendency* to produce effects that can be observed. Critical realists ultimately seek to explain observable phenomena by closely examining the underlying structures and mechanisms. As a result, critical realists view social reality as constructed and social episodes as the products of social actors' cognitive (material even if unobservable) resources (i.e., the social has to be interpreted and understood). Scientific enquiry for critical realists is directed at the interrelated strata of reality and this assumes the form of a 'vertical' explanatory approach where an ordered sequence of mechanisms is studied in terms of how the lower sequence – the phenomena that occur – explain the higher sequence – the structures that endure – without replacing the higher sequence or reducing the higher sequence to the lower sequence (Collier, 1994, p. 48).

3.1.3 Epistemology of Research

Epistemology is about what and how we can know about what there is to be known. It is about the possible ways of gaining knowledge of social reality, whatever it is understood to be. In short, epistemology deals with claims about how what is assumed to exist can be known (Blaikie, 2000). Epistemological assumptions can be *objective*, i.e. the belief that knowledge exists whether we are conscious of it or not; *constructionist*, i.e. the belief that we come to "know" through our interactions; or *subjective*, i.e. that everyone has a different understanding of what we know.

Epistemologically, critical realism seeks to explain the relationship between experiences, events and mechanisms. Hence, the questions of ‘how and why’ a particular phenomenon came into being, got its specific character and so on, are emphasized in this perspective. For critical realists, the ontological is prior to the epistemological as knowledge is incidental of our being in the world and not *vice-versa*. Before we can know how we know, we need to have some idea of how we interact with that world in such a way as to acquire knowledge of it’ (Collier, 1994, p. 137). In order to reveal underlying mechanisms of reality, it is necessary to have hypothetical descriptions (models) such that, if they existed and acted in the postulated way, they would account for the phenomenon being examined. Underlying mechanisms can only be understood by constructing ideas about them. The ontological orientation is thus towards an inquiry into ‘the properties that societies possess’ while the epistemological orientation is towards an engagement with ‘how these properties make them possible objects of knowledge for us’ (ibid.,p. 137). Hence, it is necessary to develop an idea of what societies and people actually are, and this can be discerned from the implicit knowledge we possess by virtue of being people and thus social beings. The task of transcendental realism is to render this ‘connatural knowledge’ explicit.

Despite the convergence of positivism and critical realism on the nature of science as empirical, rational and objective, aimed at providing a true explanatory and predictive knowledge of society, critical realism insists on a strict difference between explanation and prediction. The primary objective of social science is explanation, i.e. the discovery of the necessary connections between phenomena, by acquiring knowledge of the underlying structures and mechanisms at work. It is only by doing this that we get beyond the ‘mere appearances’ of things, to their nature and essences.

Critical realists rely on a *retroductive* strategy which begins from the level of the actual and seeks to understand the connections between phenomena. To explain these connections and relationships, the existence of real structures and mechanism is postulated. Thirdly, the plausibility of these postulated structures is tested/demonstrated. One theory often associated with the realist epistemology is *Grounded Theory* which insists that theories of human action are literally ‘grounded’ or ‘discovered’ from the data, rather than predicted beforehand.

The strength of critical realism includes the idea of stratified ontology described above. By distinguishing the empirical, the actual and the real, it conceives of the world as an open system which can be researched. Also, critical realism acknowledges the causal power that social structures and human agency exhibit. ‘Social practices are concept-dependent; but, contrary to the hermeneutical tradition in social science, they are not exhausted by their conceptual aspect. They

always have a material dimension' (Bhaskar, 1989, p. 4). For explanation to be complete, therefore, both the structure and agency are important. Thirdly, by conceiving the world as an open system, it inevitably allows for the plurality and contingency of causation. This gives the social researcher the freedom to explore multiple causation and their interaction with each other. Another implication of this stance is methodological pluralism. In summary, three advantages of the critical realist position as against the relativist stance can be identified:

first, critical realism enables an analysis that can consider why people draw upon certain discourses, by proposing that the extra-discursive provides the context from which the use of certain discourses is more or less easily enabled; second, critical realism can explore the impact of material practices on discursive practices; and, third, this approach does not only map the ways in which participants use discourse in order to construct particular versions of reality, but it also positions their talk within the materiality that they also have to negotiate (Sims-Schouten et al., 2007, p. 103).

In studying environmental degradation, critical realism emphasizes that scientific explanations of environmental change are partial in their description of complex biophysical processes (Forsyth, 2001). A realist political ecology assesses the political 'construction' of 'ecology.' It highlights elements such as environmental activism (Bryant and Bailey, 1997) and the role of discourse in 'constructing' environment (Peet and Watts, 1996). Furthermore, a critically realist political ecology "seeks to understand ecological change through epistemological scepticism but ontological realism to underlying biophysical processes (e.g. environmental degradation)." This implies that "biophysical reality is 'externally real' to human experience, because all knowledge, we have of such reality is partial and socially constructed" (Forsyth, 2001).

However, critical realism has been criticised for not having a systematic method for distinguishing between discursive and non-discursive leading to an individualistic criteria for selection. In other words, critical realism is said to fail to provide the criteria for deciding what is real and what is not. Also, some have argued that what critical realists present as extra-discursive can in fact be analysed from a relativist perspective, that is, it can be conceptualized as a discursive accomplishment (Edwards et al., 1995).

3.2 Research Design

3.2.1 Methodological Triangulation

The methodology used in this research is pluralistic, mixing in-depth interviews with survey data (Denzin, 1970). This is in line with the realist epistemology/ontology that underlay the whole

research, that is that reality is stratified; on the one hand social objects have a real on-going existence irrespective of what we know of them, while on the other hand they are affected by the way they are construed (Sayer, 1992; Sayer, 2000). Triangulation sees as false the claim that quantitative and qualitative methodologies are incompatible (Sarantakos, 1993; Silverman, 1993; Holstein and Gubrium, 1995).

The field research aimed to: investigate *fadama* agriculture in two villages in North Central Nigeria (Karshi and Badeggi), study traditional methods of soil, water and crop/animal management, assess the productivity (including sale and storage of crops) of *fadama* smallholders and determine extent of agrochemical use. The overall aim was to assess the sustainability and productivity of *fadama* agriculture for food security among smallholder farmers.

The research strategy was mixed techniques led principally by a core interview schedule (i.e. the leading strategy). This is complemented by a follow-up strategy, i.e. survey techniques which were used to accurately measure the demographic features of the research participants and the extent of agrochemical use. Qualitative technique (Grounded Theory, GT) was used to relate these measures to other prevailing factors such as power relations and rationale behind decision making (Bryman, 2001).

3.2.2 Grounded Theory

Since its 'discovery' by Glaser and Strauss in 1967 GT has increasingly been used in qualitative research. It is particularly suited for the purpose of theory development (Strauss and Corbin, 1994; Strauss and Corbin, 1990; Glaser, 1994; Glaser, 1999; Charmaz, 2000; Parse, 2001). Unlike with many methods where the research moves deductively (from the general to the particular), GT research proceeds inductively (from the particular to the general). Theory is generated from data and no effort is made to impose theory on data (Stern, 1985). GT is concerned with expanding an explanation of a phenomenon through the identification of the phenomenon's key elements and then categorizing the relationships of those elements to the context. It pays attention to the specific while not ignoring the uniqueness of the subject of the study (Glaser and Strauss, 1999).

GT acknowledges the active role participants in a research play in creating meaning. As a result, social processes present in human interaction are taken seriously (Hutchinson, 1993) with the sole aim of discovering patterns and processes and understanding how a group of people define, via their social interactions, their reality (Stern et al., 1982). The chief role of the researcher therefore, is to understand what is going on 'on ground' and how people manage their roles. As a result, observation, conversation and interviews are key tools for the GT researcher. After each data collection session, the data is analysed, key points noted and comparisons made.

The heart of GT research is constant simultaneous comparison and analysis of data which is compared with every other item of data and from which a theory is then generated (Glaser & Strauss, 1967). Thus, it combines data collection, analysis and theory formulation all of which are seen as connected in a reciprocal sense. However, there is hardly any agreement on how researchers can implement procedures (Glaser and Strauss, 1967; Strauss and Corbin, 1994; Seale, 1999; Charmaz, 2000). What is important though is that during the process of coding (i.e. identifying, naming, categorizing and describing phenomena) links between categories, or core category are identified and theoretical propositions noted as they begin to appear. As the categories and properties emerge, they and their links to the core category provide the theory.

In this research, standard GT methods of theoretical sampling, concurrent data collection and analysis using open, axial and theoretical coding and a story line technique to develop the core category and category saturation were used. The use of 'theoretical' sampling in GT increases sample diversity and eventually leads to a richer theory (Glaser and Strauss, 1967; Glaser, 1978; Becker, 1993). Consequently, at the beginning, there was no limit to the number of data sources (participants, interviewees, and so forth). Data was collected and accumulated until nothing new was being said. The selection of participants (and other sources of data) was a function of the emerging hypothesis and the sample size a function of the theoretical completeness (Baker et al., 1992).

3.2.3 Rationale for Choice of Method

Triangulation as a method seeks to avoid simple generalizations and enables a more comprehensive understanding of social phenomenon (Sayer, 2000; Danermark, 2002; Carter and New, 2004). By integrating different methods, triangulation seeks to achieve completeness, reliability and validity which can be achieved through a convergence of perspectives. Also, it reduces the risk of bias and related weaknesses that come from single methods.

The choice of the *constant comparison* method of data analysis is in line with GT methodology which has at its heart constant, continuous and simultaneous interaction between data collection and analysis. This, in turn, is in line with the philosophical assumption underpinning this research, i.e. critical realism. It starts by accepting the existence of the 'real' but moves beyond that towards something more fundamental in which the possibility of that which is actual is grounded.

Content analysis in GT is done by means of *coding* which consists of identifying and labelling the key concepts in each transcription. This happens in three complementary stages: (1) open coding: this involves giving meaning based on labelling concepts mainly relying on the analytical strength

of the researcher. The focus here is on the words of participants and also what is observed and looking for concepts with an open mind. Every new theme is inductively taken into account and a category system is established. Through 'open coding' the thoughts, ideas and meanings contained in the properties and dimensions of data collected were identified. (2) axial coding: this stage of coding enable the researcher to develop main categories and sub-categories (Pidgeon, 1996; Strauss and Corbin, 1998). The aim is to identify higher-level category by identifying connections between a particular category identified in open coding and their relating categories (3) axial coding: this stage of coding is meant to integrate the main and sub- categories identified in open and axial coding respectively. According to Strauss and Corbin (1998), during the process of open coding and axial coding core category that best hold and central to all other categories together should emerge with high frequency of mention (explicitly or implicitly). A substantive theory is generated that tells the wider story.

In addition to GT analyses (in line with the qualitative and intensive nature of this research), descriptive statistics are used to illustrate the basic features (numerically and graphically) of and direction of the data (Lawson, 1996; Lawson, 1999). With the aid of the statistical software SPSS (Statistical Package for the Social Sciences), a complete survey of the data collected on the farmers (age, income, sex, education, risk awareness and related variables) was summarized using means, medians and correlations. GT analyses helped me to achieve a more critical and reflexive interpretation of the statistics generated and hence avoided the often simple, general and impersonal nature of statistics (Harding, 1995; Nelson, 1995; Ribbens and Edwards, 1998).

3.2.4 Literature Review in this Thesis

Debate on the place of literature in GT is still fierce between those who view GT as a tool for theory generation from the research situation and hence encourage little or no access to literature and those who maintain that some theoretical knowledge is not only necessary but inescapable (McGhee et al., 2007). In this research, literature was treated as emergent (Strauss and Corbin, 1998). Whereas relevant literature was accessed before the research, care was taken to make sure that my theoretical knowledge of the literature did not constrain the process of coding and memoing. Hence, literature on issues arising from the field and on GT itself were not altogether rejected but were accessed as they became relevant. In many cases, therefore, the literature is incorporated in the data analysis section. Sometimes the literature threw more light on the situation on ground and at other times, data from the field challenged the literature. For instance, whereas much of the literature see agriculture in strictly economic terms, results from the field show it in the multi-functional role it plays in the lives of rural people. The exercise of

reflexivity helped me to reduce bias and distortion of data (Robson, 2002; Neil, 2006). In addition, a comprehensive literature review was carried out after data collection/analysis in order to situate the research within the wider theoretical issues on agriculture and the global food economy, sustainability and smallholders especially as they relate to developing countries.

3.2.5 Difficulties with GT

Grounded theory is generally cumbersome and sometimes mechanical (especially when it is equated simply with theory testing, content analysis and word count). Other difficulties with grounded theory involve literature review since it is assumed that prior knowledge in grounded theory will not only contaminate a researcher's perspective but also force the researcher into testing hypotheses, either overtly or unconsciously, rather than directly observing them. This researcher, however, agrees on the need for some literature review and argues that because grounded theory research requires interpersonal interaction, the researcher is inevitably part of his or her daily observations (Hutchinson, 1993, p. 187).

3.3 Methods and Instruments of Data Collection/Sampling

In line with my methodology, i.e. grounded theory, purposive/theoretical sampling was employed in the earlier part of the research while in later phases, a systematic relational or variational sampling was frequently employed with the objective of locating data that either confirmed the relationships between categories, or limited their applicability. The final phase generally involved discriminate sampling, which consisted of the deliberate and directed selection of individuals, objects or documents to verify the core category and the theory as a whole, as well as to compensate for other, less developed categories.

In this research, the unit of analysis was individual farmers because small group research and I was interested in studying individual farmers to understand their farming practices and the decision making process. Sampling began by interviewing 'significant' individuals or 'gatekeepers' – in this case, representatives of the village heads in the area of study and on ground agricultural extension workers who were familiar with the terrain and the farmers. They also have the requisite knowledge and experience (Lincoln & Guba, 1985). This initial sampling was broad-based (Glaser, 1978; Morse, 1991; Hutchinson, 1993) and in this case covered the general subject of *fadama* agriculture. However, the data obtained did not necessarily dictate the line of enquiry as subsequent interviews shed more light on the fullness of the phenomenon under study (Cutcliffe, 2000).

Data was generated mainly through observation, interviews and document analysis. Observation was complemented by interviews which moved from being initially purposive (targeting the gatekeepers in the farming communities) to include farmers in real on and off-farm situations. Over sixty (60) farmers who practice *fadama* agriculture were interviewed and their farming practices (with their family histories) were carefully assessed. Thus, the interviews covered all areas of *fadama* agriculture from land preparation to storage. Similarly, about twenty (20) individuals involved with the Ministry of Agriculture, donor agencies (especially the World Bank) and the academia were interviewed with a view to investigating the thinking that shapes agricultural policies affecting smallholders especially *fadama* users. Interviews were complimented by observation and ethnographic notes made over a period of about four (4) months. In addition to these, government policy documents and reports on agriculture were carefully analysed.

3.3.1 Observation/Participatory Action Research

The first method I used for data collection is unstructured observation. As explained by Langley, observation involves looking and listening very carefully with the aim of discovering particular information about people's behaviour (Langley, 1988). Observation aims at 'real life' in 'real world' and has the obvious advantage of being direct (through watching and listening) and this compliments information collected through other techniques (Robson, 1999). However, it has the obvious problem of affecting the situation under observation and it is time consuming (Ibid. pp. 191-192). Observation also depends on the way people perceive what is being said (Bell, 2005, p. 184)– that is, observers sometimes 'filter' and this can lead to bias/misinterpretation. This notwithstanding, observation is crucial in the exploratory phase of research as it reveals if people do what they say they do.

The choice of observation as the starting point in this research was because, despite having some knowledge of *fadama* farming, I did not have definitions or structures but instead hoped to develop conceptual categories from the data (Bowling, 2002). These unstructured observations were carried out in Karshi village, a *fadama* farming community, in the outskirts of Abuja, the Federal Capital Territory of Nigeria and in Baddeggi, a similar farming community in Niger State. I observed the farmers both on their farms, in the markets, at their homes and during village communal activities. The sole purpose of the observation was to gain insight into the role that small-scale agriculture plays in the lives of the people and how it shapes other spheres of the people's lives. Also, the different roles played by men, women and children in relation to agriculture was observed as well as the general methods and practices of *fadama* farming, including the types and level of external inputs and agrochemicals used.

Direct observation enabled me to study the villagers in their ‘natural setting’ and see how they relate to their primary means of livelihood, that is, land and water, through the practice of *fadama* farming. The obvious advantage of observation is that it is detailed and hence provided me with a richer and deeper source of information than a simple survey would have done. It also allowed me to study the whole group over time especially since I am interested in community dynamics with specific reference to agriculture and its importance in the lives of small-scale farmers.

I had initially planned not to be a participant but an unobtrusive observer so as to get a more detached perspective about the sample situation I was observing. However, the reality in the field forced me to assume a more participatory role as I became more actively engaged in the research process by participating and helping the farmers perform simple tasks around the farm. By being an active participant in both dialogue and collaboration, I developed a relationship of trust with the farmers that allowed them to be more relaxed and honest in their responses. Thus, observation became charged with action research features of self-reflection aimed at understanding and improving the rationality and justification of the practices of the research participants (Carr and Kemmis, 1986; Burns, 1999). Also, direct involvement helped me in pursuing the dual aims of producing direct and relevant knowledge to the *fadama* farmers as well as empowering them through this process of constructing and using their knowledge (Reason, 1998).

The primary tools I used in my observation were a digital recorder and occasionally a notebook. After every observation/interview session, I made general notes paying attention to emerging patterns. Hence, the whole research project was a process of looking for more evidence, confirming them and comparing them with each other.

3.3.2 Interviews

The bulk of the data in this research was generated through interviews which, coupled with the other methods helped me to develop a theory. Interview is ‘initiated by the interviewer for the specific purpose of obtaining research-relevant information and focused by him/her on content specified by research objectives of systematic description, prediction or explanation’ (Cohen and Manion, 1989, p. 307). In line with my GT methodology, my first interview sample was purposive and in this case, covered primarily the gatekeepers of both Karshi and Baddeggifarming communities. As explained above, grounded theory benefits when the first sample concentrates on people who are knowledgeable about the case under study. My first sets of interview thus covered the authority figures in the two communities, i.e. members of the village council and extension officers of the ministry of agriculture stationed in the two communities. This gave me an insight into the substantive issues I was to investigate. Furthermore, starting with gatekeepers allowed me

to scale the initial hurdle of selecting participants for the research as these gatekeepers were familiar with the terrain and the people active and in direct connection with the study population. An important person of authority in the two communities was the *sarkin noma* (the head farmer) who sits on the chief's council and oversees issues relating to agriculture and livestock. My second sets of interviews covered the individual farmers, both men and women, government officials, officials of the WB and members of the academic community in some institutions of higher learning in Nigeria.

In the first interviews, the main question I was asking was: what does *fadama* agriculture entail and how does it shape rural livelihood? In other words, how do the people construct their livelihood(s) around *fadama* agriculture and how does it shape other forces in the community. Being primarily farming communities, I asked about the seasons (rainfall, drought), criteria for farming, choice of farming methods, knowledge of soil types and how all these affect farming and community life as a whole. Secondly, I asked questions about the use of agrochemicals/machinery and how the introduction and use of simple farming technologies by the government and the WB, have transformed enriched or eroded traditional farming practices, boost production, affected social structures, and how the people perceive the government and donor agencies.

My core interview schedule was semi-structured and in-depth as my aim was to explore the *fadama* farmers' point of view, feelings, practices and perspectives on agriculture. By so doing, I hoped to gain useful information especially as my research participants were considered the experts and me, the learner. Whereas my observations helped me to assess group and community norms, in-depth interviews were useful for learning about the perspectives of individuals and how they interpret and order the world. Interviews were also appropriate in this case because farming involves structures and sensitive topics such as power relations and gender which are better explored individually than in the group.

In the interviews, I used open-ended questions and a semi-structured format to allow for richer responses instead of the simple 'yes' and 'no'. I mostly used a tape recorder instead of taking notes so as not to affect the conversational atmosphere I wanted to create with my research participants. The format of my interview followed the standard rule of schematizing which include clarifying the purpose of the interview, designing and developing the interview guide, the actual interviewing, transcribing and finally analysing. The actual interview involved active listening, flexibility and recording. Most of the interviews took place on farms as most farmers would not accept to schedule interview during working hours when they were most likely to be busy on the farms. This sometimes required some kind of prior agreement but was often random as most farmers agreed

to talk to me when I visited them on the farms. I documented the interviews by means of digital recordings and subsequently field notes.

The second set of interviews covered government officials, representatives of the WB and members of the academia. Combined, they represent the policy engine especially with regards agriculture. Hence, I was interested in investigating their understanding of smallholder agriculture and its role in ensuring food security and reducing poverty. Beyond their analysis of what the problem of agriculture in Nigeria is, I was equally looking at their suggested solutions and means of achieving the goal of reducing hunger in Nigeria. Finally, I wanted to understand their perception of sustainability vis-à-vis agricultural mechanization/modernization and the use of external inputs which typically characterize most of smallholder agriculture in Nigeria.

My choice of in-depth interview was because of its flexibility and adaptability – it was face to face and hence it allowed me to observe the interviewee's non-verbal signs and to modify my line of enquiry. However, interviews require skills and experience, they were time consuming and sometimes difficult to obtain cooperation. Also, there were ethical considerations followed when carrying out interviews (informed consent, confidentiality) and these were carefully considered at the start of and during the actual research. I refrained from creating false expectations and avoided incidental remarks. In addition to these ethical concerns, to be effective as an interviewer, I familiarized myself with the research documents (consent form, interview guide/schedule), practiced interviewing and the use of the equipment before the interview itself. Consent was sought from all research participants orally as many of the farmers were not literate and generally sceptical about thumb printing a document.

The core skills I required to establish positive interviewer/participant dynamics included rapport-building, emphasizing the participant's perspective and accommodating different personalities and emotional states and taking notes strategically (usually after each interview). I learnt to manage an interview through role clarification, time management, among others.

3.3.3 Survey Methods

The use of flexible semi-structured interview survey method was employed in this research to gain understanding into attitudes, behaviours and opinions of the farmer population at a given point in time (Babbie, 1973; Babbie, 1995; Allan and Skinner, 1991). The mode of data collection was direct (in-person) and the basic method of purposive sampling was employed as was the case with the qualitative interviews and observations. Factors such as demographic characteristics and attitudinal variables such as preferences, styles, goals and endorsements were captured using survey methods.

Behavioural variables (such as education, health/safety, and consumer patterns) and opinions (beliefs, evaluations, judgements and satisfactions) were equally recorded in the same way. I used oral survey method which allowed me to cover a wide range of issues within a limited amount of time that each interview permitted. The questions asked were open-ended and most of the responses were simple yes/no. The advantage of using qualitative semi-structured interview survey method was that it allowed for flexibility, adaptability and freedom (Rea and Parker, 1992; Alreck and Settle, 1995). Also, by using the same interview guide, the same general areas of information were collected from each of the interviewees. It should be said that all of the methods of data collection overlapped with each other in line with my method of triangulating data sources which allowed me to gather all data possible and relevant.

3.3.4 Secondary Sources

The use of secondary data afford the researcher access to information already processed and thought out than data from primary sources (Creswell, 2003). Secondary data used in this research included printed and recorded material, published information (books, journal articles, government publications, statistical records, newspapers, magazines, conference proceedings, annual reports and archival data) and electronic sources (online databases, the internet, and CD-ROMs). These data, accessed from libraries, books and the internet, enriched my understanding of the context, impacts, needs, and objectives of the subject matter under study. Also, secondary data allowed me to make comparisons and identify patterns (strengths and weaknesses) of the different approaches to the area of my study. However, accessing government documents and statistics on Nigeria and the agricultural sector proved hard as the system of data storage was inefficient and information was generally hard to come by.

3.4 Reflexivity and the Construction of Meaning in Research

The role of the researcher in contributing to the construction of meaning in the research process has been increasingly accepted especially in qualitative research (Neuman, 2000). This agency exercised by the researcher, his/her influence and biases and the impossibility of a *tabula rasa* approach to the conduct of research has been referred to as *reflexivity* (Nightingale and Cromby, 1999). Alongside this personal reflexivity (how a research is shaped by the researcher's beliefs and values) is epistemological reflexivity which is the process of reflecting upon the assumptions and their implications made by the researcher in the course of the research (Willig, 2001). Principally, the latter is concerned with how the research design has shaped the research outcome and how a different understanding of the phenomenon could arise under different circumstances. The

importance of reflexivity is that it helps to limit individual bias and illusions (Bourdieu and Wacquant, 1992), enables actions to be understood within their particular context (Garfinkel, 1967), explains the relationship between researcher and those researched (May, 1998), and helps to better understand the ontological structure of the group being studied instead of imposing those from an already dominant culture (Worsley, 1997).

The ability to identify one's bias and how it influences the research project demands a critical self-reflection, self-scrutiny and analysis. This is essential in order to avoid imposition or appropriation of experiences (England, 1994). Hence, I was constantly aware of my position as a young male researcher from Northern Nigeria and how my background and education have shaped my understanding of the reality of rural dwellers and the gap that exists between me and the farmers despite my activeness in the research project and the strong sense of familiarity I felt with the farmers and their agricultural system. My openness to their experience and eagerness to learn and participate in the farmers' activities enhanced the quality of my relationship with the farmers and hence that of the data I generated.

Similarly, I was aware of my personal bias in favour of smallholders and sustainable agriculture. Firstly, this was the result of my own background which exposed me to smallholders early in life. Even though I was not particularly too familiar with the details of *fadama* agriculture, I had some vague idea about what it was about and I had seen markets where *fadama* farmers sold their farm produce. Secondly, my personal interest in climate variability and how it affects Africa contributed in my decision to study *fadama* smallholders whom I believe will form the core of the people who will suffer most from its consequences. The persistence of smallholder farmers alongside the formal sector despite attempts at modernizing or obliterating their practices also spurred my interest in them. Thirdly, my interest in African traditional knowledge systems and their potential to sustainably increase the productivity of smallholders if properly harnessed was an apparent bias. Also, my suspicion of government's sincerity in securing the welfare of smallholder farmers and an equally strong suspicion of policy recommendations of international organizations like the WB were instrumental in my decision to study *fadama* agriculture in the first place.

I was also always keenly aware of the biases of the farmers themselves and other participants (like government officials) in the research project. For instance, farmers' responses were sometimes intended for an 'outsider' to elicit a given emotion (for instance, sympathy). Also, due to constant interaction with outsiders (researchers, donor agencies, NGOs), the farmers sometimes tend to give the answers they perceive the outsider wants to hear. However, that I spoke the language and participated in many of their activities mitigated some of these biases. In general, however, I

remained aware of all these factors throughout the research not necessarily because they were seen to be negative but so that I could better understand how they affect the whole research project. I was equally aware of the bias of the elite towards 'modern' farming practices.

Finally, this research has been a journey for me as my thinking was continually evolving in light of data collected. An example of the different transitions in this intellectual journey is the change of my initial hypothesis which previously assumed that informal methods and practices of *fadama* agriculture were being co-opted into mainstream policies by the government and donors (the World Bank). However, findings from the field did not confirm this leading to a change in hypothesis and a modification of the research question.

3.5 Research Limitations

Every research has its peculiar challenges depending on the specific context within which it is carried out (Katz, 1994; Myers, 2001; Scott et al., 2006). Such constraints could range from language to cultural barriers. In my case, the first and most important challenge I faced was that the reality of *fadama* agriculture that I was confronted with was different from what I had in mind. My initial hypothesis was that international institutions like the WB were involved in a shifting of paradigm (from top-down to bottom-up) through the co-option of *fadama* and *fadama* farming practices. However, I found out that the influence of the WB was remote - mainly through its efforts at modernizing *fadama* agriculture. Also, I had assumed that *fadama* agriculture presented a perfect example of sustainable traditional agriculture. Nevertheless, what I found out was a system that combined elements of traditional agriculture and those of conventional agriculture like external inputs (agrochemicals) in an unstable manner.

Secondly, initial access to the farmers was difficult because of religious barriers. Most of those interviewed were Muslim women who were under certain religious restrictions (*purdah*⁵) and this meant that I could only interview the women in the presence of a man (the husband, son, or the extension worker). This clearly impacted on the quality of response I got. However, after weeks of visiting the community and establishing a relationship with the villagers, I was able to overcome this obstacle and in my second round of interviews I got more honest responses from the women farmers.

⁵ The term *purdah*, means "curtain," and refers to the traditional seclusion of women in parts of the Middle East and Southeast Asia. The practice is particularly linked to Muslim and Hindu societies. In recent times, the *purdah* has been the subject of intense debate with some people viewing it as a tool for women suppression. Though often associated with religion, the practice of *purdah* is generally cultural. However, it has been defended on the basis of religious values about of modesty and proper comportment.

Additionally, the farmers were generally suspicious of outsiders and even though I spoke the language, they were initially cautious in their responses. Likewise, they had initially taken me for a government official and were antagonistic. This was partly due to the fact they consider the government to be apathetic to their plight and condition. Also, they were quick to dismiss me as just another ‘talker’ with no action. It took concerted effort to explain to them what I was about as a researcher. Once they understood this, they were welcoming and cooperative.

The most significant challenge I faced was accessing government officials and information. It was only after repeated calls at the World Bank office in Abuja that I was able to see an official and schedule an interview which took several more weeks to actually take place. Government officials and representatives of NGOs were generally apprehensive of my presence and saw me as scrutinizing their work. Also, government/public libraries, as well as university/research centre libraries were often empty or lean on resources.

Furthermore, I had to adjust my schedule to suit the farmers’ who refused to set aside time for interviews which they considered to be a misuse of their time. This meant I had to wake up early (5-6 am) to meet up with them while still on the farm. Other related difficulties included risks from movement to/from field sites. It included low level risks such as road traffic accident, falling on uneven or slippery surfaces; cuts from sharp objects and exhaustion. To manage this, I ensured vehicle safety, wore boots while in the field. I also carried simple first aid and took a break when necessary. The weather conditions were adverse and I wore appropriate clothing and withdrew to a cold environment when necessary.

3.6 Conclusion

Despite its many advantages, GT is a painstakingly precise method of study and required high levels of both experience and acumen which I did not quite possess at the beginning of the research but which I acquired in the course of my research and through constant clarification of the literature. To be a good interviewer, I had to be a good listener, able to notice and react to nonverbal clues, flexible, open minded, and willing to release power and control. It was important for me to digest the literature on GT and the methods of data collection. Also, a lot of practice was necessary and I had to carry out a few pilot interviews and observation. Finally, the training received on research methods was very helpful in the course of this research.

CHAPTER 4

FADAMA AGRICULTURE IN KARSHI AND BADDEGGI

4.1 Research Background

4.1.1 Study Area and Participants

The participants were rural farmers in two small agrarian villages in North-Central Nigeria: Karshi and Baddeggi. Karshi is a village in the outskirts of Abuja, Nigeria's capital city, which covers a land area of 8,000 square kilometres and is located in the middle of the country. Abuja falls within latitude 7° 25' N and 9° 20' North of the equator and longitude 5° 45' and 7° 39'. Karshi it is about 50 km from the Abuja main town and consists mainly of rural indigenous communities mostly engaged in farming and related activities. The predominant ethnic groups in Karshi are the Gwari, Gwandera and Gwandu. The major *fadama* areas in Abuja (including those in Karshi) are found along the floodplains of the major rivers that drain the Federal Capital Territory (FCT). The presence of Hausa migrants within the FCT has made dry season *fadama* farming popular in the area.

Baddeggi is a small district of Bida town, the second largest city in Niger State. Bida sits on the Bako River, one of the several minor tributaries of the Niger River. It is approximately 100 km/60 mi southwest of Minna and 200 km/120 mi northeast of Ilorin and falls on Latitude 9° 4' 60 N, Longitude: 6° 1' 0 E. Baddeggi is a major trade centre for rice, which is mainly cultivated in the *fadamas* (i.e. floodplains) of the Niger and Kaduna rivers. It is predominantly inhabited by the Nupe people. Due to their proximity to the Niger-Benue⁶ river systems and their tributaries, most of the inhabitants of Karshi and Baddeggi are farmers involved in *fadama* agriculture (fig 6).

⁶ The Niger River traverses four countries and is West Africa's longest (over 4,180 km) and principal river. Its basin spreads over ten countries. The Benue River is the longest (approximately 1,400 km) and main tributary of the Niger River. It rises in Chad and flows across east-central Nigeria (FAO, 1997).

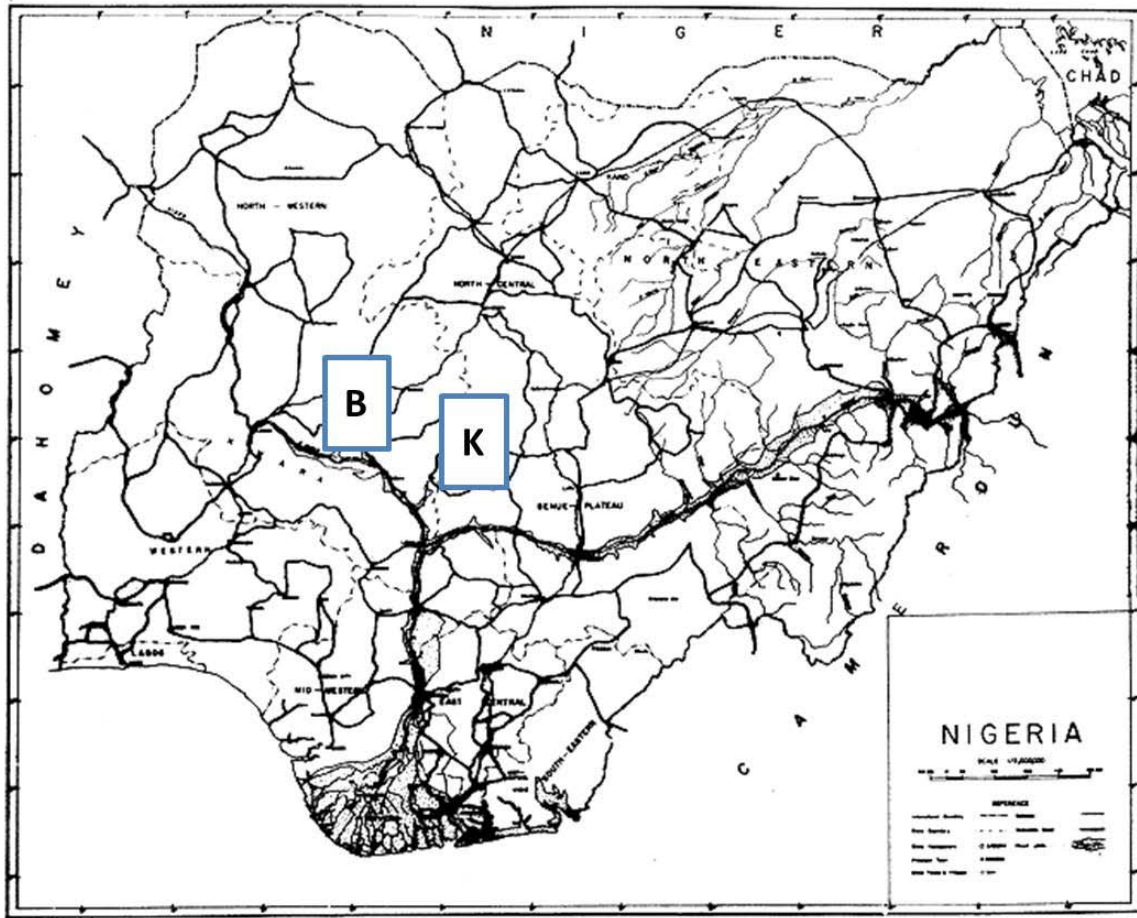


Figure 6: Map of Nigeria showing the main floodplains of the Niger-Benue system & the location of the case study areas (K= Karshi, B= Baddeeggi)
Map Source: (Awachie, 1976)

Karshi was the core study area and provided the bulk of the data for the research while Baddeeggi served as a comparative study of the similarities and differences (if any) with Karshi and the underlining general structure that generates them. Comparative study allows for generalisation of categories of collected data and for similarities and differences of data under the same category to be studied. Also, the theory generated from such a study is broadened.

In all, forty seven farmers (47) were interviewed in Karshi and twenty one (21) in Baddeeggi. All the participants in the research are involved in the traditional cropping system called *fadama* farming. This practice involves the use of low-lying aquifers (floodplains) which retain moisture during the dry season and therefore provide easily accessible shallow groundwater (Turner, 1985; Dabi and Anderson, 1998). The interview schedule and questionnaire covered areas relating to the socio-economic characteristics of *fadama* users in both areas, source of income and labour, plot size, access to extension, practices of resources management, use of external inputs and factors affecting decision making.

4.1.2 Choice of Study Area

A number of reasons prompted the choice of the study areas. Both areas demonstrate the role of *fadama* within traditional management practices and fall within a similar geographical setting. However, the level of state intervention in *fadama* lands is higher in Baddeeggi where some *fadama* lands have been somewhat transformed over time in an attempt to ‘modernize’⁷ *fadama* production. On the other hand, *fadama* lands in the Abuja territory have not been significantly developed as in other parts of the Niger-Benue trough of the middle-belt of the country (Balogun, 2001). Recently, however, many people in these areas have become involved in the all year practice of *fadama* farming making it an important source of subsistence and livelihood and hence a vital tool for food security, poverty reduction, labour provision and also a check on urban-rural migration (Dabi, 2004). Overall, state intervention in Karshi appears limited to development and expansion rather than an attempt to ‘modernize’ *fadama* lands and farming systems. Relatedly, one of the national agricultural research institutes is located in Baddeeggi (the National Cereals Research Institute) making it more accessible to agricultural extension workers and agricultural inputs. Alternatively, Karshi is remote from any research institutes. This difference allows for comparison with regards the impact of extension/input access on resource management and sustainability in the two areas. Another reason for choosing the study areas is the similarities in the agricultural practices in the two areas: they consist of a combination of ‘traditional’ methods of cultivation using ‘simple’ tools and ‘modern’ inputs. Also, the sustainability of the farming systems in the study areas has not sufficiently studied. The literature on the sustainability of *fadama* farming in light of increased agrochemical use by smallholder *fadama* farmers in many parts of Nigeria is very narrow. Thus, a study of the sustainability of *fadama* agriculture and the effects of external inputs such as chemicals on *fadama* lands is very important because of the relevance, diversity and ecological importance of *fadamas*. Furthermore, the two communities share certain cultural and socio-economic characteristics. However, whereas women are heavily involved in agriculture in Karshi, their role is limited in Baddeeggi. Furthermore, the two study areas are easily accessible by road and are linked to nearby major cities through trade. However, whereas Baddeeggi has a well-established market structure, the system in Karshi is still largely underdeveloped and informal. Despite their linkage to the market, however, both areas are predominantly rural. Finally, *Hausa* is widely spoken in both communities making it easy for me communicate with the farmers and their families.

⁷ Modernization of *fadama* lands mainly refers to attempts by the Nigerian government to transform agricultural production in *fadama* areas through large-scale irrigation schemes and dam building.

4.2 Results and Discussions

This subsection examines some of the socio-cultural and economic characteristics of the respondents which may contribute to or affect their productivity level and which influence their choice of agricultural methods/techniques. These include age, marital status, level of education, religion, source of income, access to credit and land ownership. Suffice it to say that this is not done to strictly analyse and test relationships as in pure econometrics but mainly to provide a simple but useful summary of the population characteristics.

4.2.1 Demographic Characteristics

In Karshi village, 47 farmers were interviewed. Of these, 27 (57.4%) were females and 20 (42.6%) were male. The high percentage of women in the sample size is purely random and may be explained by the time of the year which coincided with the time for rice planting. As in many parts of Nigeria, smallholder rice farming in Karshi is predominantly done by women. The women involved in *fadama* agriculture were asked about their spouses. The answers were varied with some saying that their husbands are also farmers (mainly of tuber crops), artisans, urban workers or a mixture of one or both of the above. Others crops cultivated by women in Karshi include cowpea and a broad range of vegetables. Men in Karshi mostly cultivate tillage intensive crops like yam, cassava, sugar-cane, banana and cereals. In Baddegi, however, 81% of the respondents were men while only 19% were women. The involvement of women in both communities is also related to religious and cultural norms.

74.5% of the respondents in Karshi were Muslims, while 25.5% were Christians or practitioners of traditional religion. All of the respondents in Baddegi were Muslims. Religion is an important factor and shapes such issues as land ownership, marriage, and indeed the whole social milieu. Nevertheless, the understanding and practice of religion slightly differs in the case of Karshi and Baddegi. In the former, the majority of women were involved in farming, whereas in the latter, very few women were involved in farming due to restrictions placed on them by their husbands on religious grounds as explained by a respondent in Baddegi:

Our religion [Islam] does not allow you to belabour the women. Whatever drudgery you see the women going through here, it is as a result of poverty. Otherwise, women are not supposed to go for this hard labour thing. They are meant to stay at home while the men do all the necessary things for them. But, I think, there is a turning point now and a few of them now participate in harvesting and processing.

In both cases, though, access to female farmers was initially difficult due to religious restriction (*purdah*).

	Karshi			Baddeggi	
		Frequency	Percentage	Frequency	Per cent
Sex	Male	20	42.6	17	81.0
	Female	27	57.4	4	19.0
	Total	47	100.0	21	100.0
Farm Size	1Ha & Below	28	59.6	6	28.6
	Between 2-4Ha	19	40.4	15	71.4
	Total	47	100.0	21	100.0

Table 6: Statistical distribution of farmers based on sex and farm size in Karshi

Majority (59.6%) of the respondents in Karshi cultivate between 0.2 to 1Ha of land, whereas 40.4 % cultivate between 2-4Ha (table 6). In Baddeggi, however, a higher percentage of the respondents (40.4%) have between 2-4Ha while 59.6 have 1ha or less. The bulk of the farmers, therefore, fit into the general characteristics of smallholder farmers typical in many developing countries of Africa. Similarly, land use is intensive among the majority of the respondents as they attempt to alleviate land constraints. As in many parts of Africa, arable land is a prized commodity in Karshi and Baddeggi in light of scarcity and population growth. The problem is compounded in Karshi because of the influx of people into Federal Capital Territory (Abuja) and land loss toroad construction through the community. The pressure on land is also not helped by the lack of viable alternative employment opportunities in the non-farm sector.

The cropping pattern in the two communities was mixed cropping. Most of the farmers were involved in some kind of arrangement that allowed them to plant multiple crops, rotate them or integrate crops and livestock/poultry/fish ponds (fig 7).

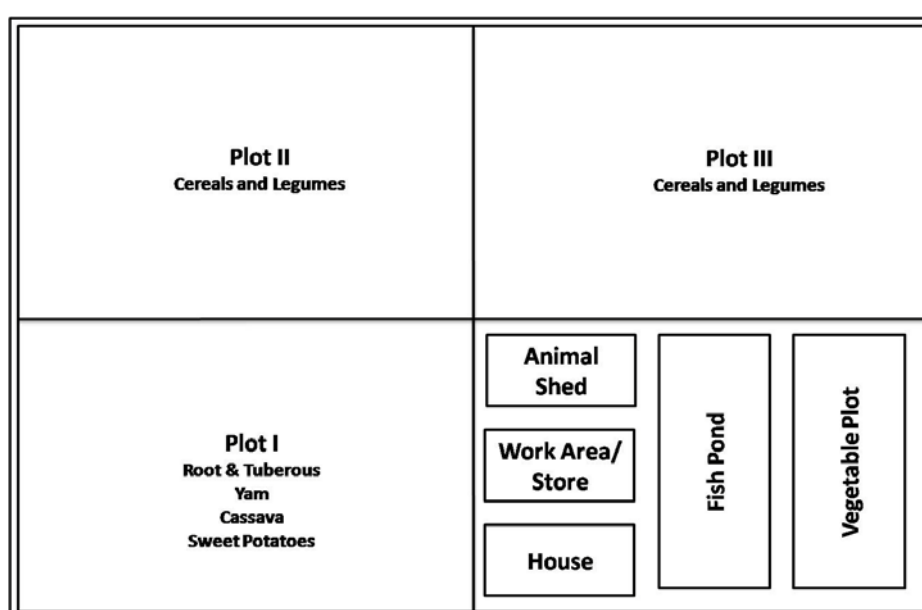


Figure 7: Schematic of a typical farmstead

Respondents in Karshi were between the ages of 29-56. The mean age of the farming sample is 37 (with the minimum being 29 and maximum 56). The modal age is 38. In Baddeggi, the age range is higher with the mean age being 43, while the median and mode ages are 42 and 38 respectively. It appears, consequently, that most of the farmers are in their prime age and therefore energetic for farming purpose. In contrast however, the age distribution shows fewer young people engaged in *fadama* farming in the areas of study. This can be explained by factors that include migration, the search for more profitable sources of income, and the fact that most male children of these farmers are enrolled in schools (primary and secondary).

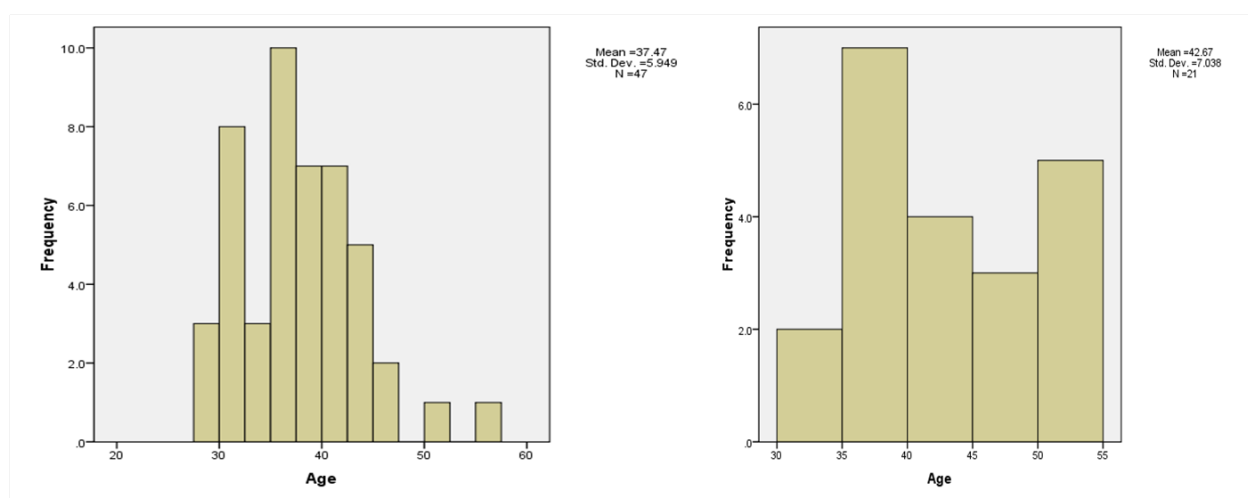


Figure 8: Histograms showing age distribution of farmers in Karshi and Baddeggi

The boxplot (fig. 9) below compares the distribution of age across sex in Karshi. The median age of males is higher and, overall, the age ranges are higher. The spread of ages, indicated by the size of the shaded boxes and the length of the T-bars, is also higher for males than for females. In Baddeggi, however, the median age of women was lower given that few women farmers were interviewed.

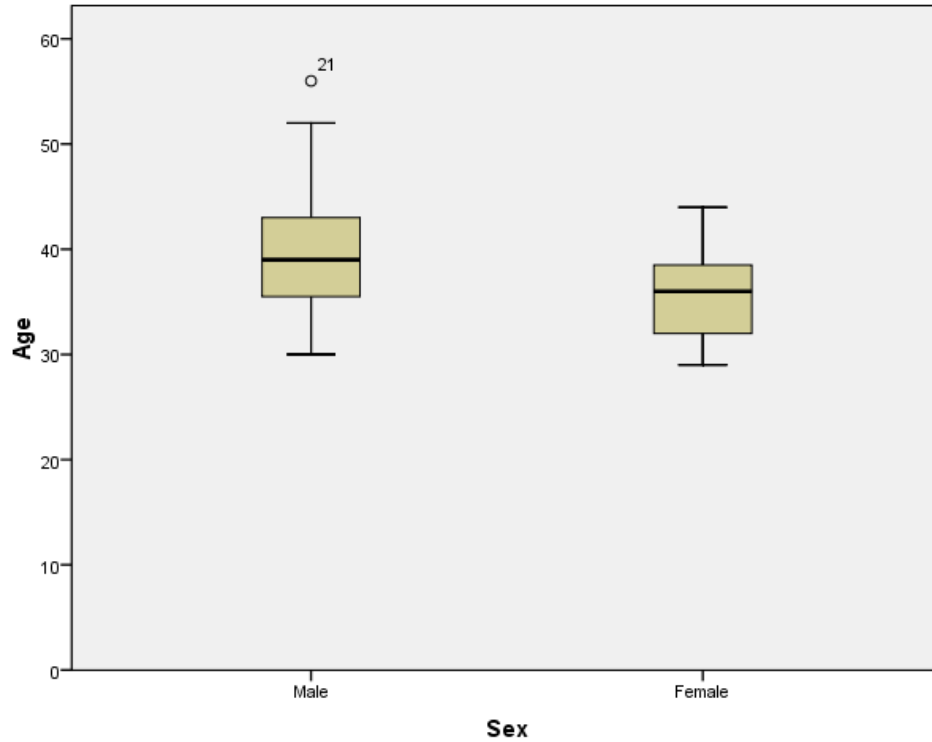


Figure 9: Boxplots illustrating age distribution of male and female farmers in Karshi

A cross tabulation of sex and age shows significant differences in the age distribution between men and women. The data for age was recoded into 3 equal groups as indicated in below (table 7). In Karshi, none of the men respondents is between the age ranges of 20-29 and 11.1% of female respondents fit into that age bracket. 50% of men respondents fall between the age categories 30-39 in contrast to 66.7% of the female respondents (table 7). While 22.2% of the female respondents are between the ages 40-49, most of the men respondents (40%) fall within that age bracket. 2 of the men respondents (10%) fall between 50-59, with none of the female respondents within that age range. Majority of the female respondents therefore, are younger than their male counterparts in Karshi.

			Karshi				Baddeggi			
			Age categories				Age categories			
			20-29	30-39	40-49	50-59	20-29	30-39	40-49	50-59
Sex	Male	Count	0	10	8	2	0	5	7	5
		% within sex	.0%	50.0%	40.0%	10.0%	.0%	29.4%	41.2%	29.4%
	Female	Count	3	18	6	0	0	4	0	0
		% within sex	11.1%	66.7%	22.2%	.0%	.0%	100.0%	0%	.0%
Total		Count	3	28	14	2	0	9	7	5
		% within sex	6.4%	59.6%	59.6%	4.3%	.0%	42.9%	33.3%	23.8%

Table 7: Cross-tabulation of sex with age categories for Karshi and Baddeggi

Among the male respondents in Baddeggi, 5 (29.4%) were between 30 and 39; 7 (41.2%) fall within the 40-49 range and 5 (29.4%) are between 50 and 59. All the 4 female respondents are in the 30-39 age brackets. The median age of the respondents in Baddeggi is therefore higher than that in Karshi among both sexes.

All of the respondents in Karshi and Baddeggi are married, with most of the men being polygamous (only 2 of the male respondents in Karshi were monogamous). All the respondents have children, with the highest percentage (67%) in Karshi having between 5-9 dependents, which also represent the average size of most households. 33%, have between 5-21 dependents. In both Baddeggi, the mean number of children is about 8. The majority of the farmers, therefore, depend on family labour.

4.2.2 Labour

Land preparation, weeding and harvesting are mostly done manually with the help of traditional farm implements. None of the farmers in Karshi has regular access to a tractor. Thus, land preparation and weeding is often labour intensive, especially on rice farms and this in part explains the appeal of herbicides.

	Karshi			Baddeggi	
		<i>Frequency</i>	<i>Percentage</i>	<i>Frequency</i>	<i>per cent</i>
Labour	Self/family labour	36	76.6	11	52.4
	Hired Labour	11	23.4	10	47.6
	Total	47	100.0	21	100.0

Table 8: Source of labour in Karshi and Baddeggi

About 77% of the farmers in Karshi use family-based labour, often with help from other extended family members and farmer organizations (*gandu* or *gaiya*). The remaining 23%, who represent the more 'successful' of the farmers (owning between 2-4Ha of farm) employ outside labour ranging between 3-5 people to help with farm work. Among the respondents in Baddeggi, the majority (52.4%) rely on family labour and 47.6% rely at some point during the farming season on hired labour (table 8). The higher percentage of farmers relying on external labour in Baddeggi is related to the fact that more farmers own between 2-4ha of land. In general, however, hire is not very common among the respondents in both Karshi and Baddeggi. In Karshi, most of the work is done by women and their female children as preference is given to male education over female education and this means that the girl child is often at home with the mother.

The use of family based manual labour can be attributed to a number of reasons. Firstly, land preparation and weeding are feasible because the respondents farmed small farm sizes (between 0.5-1Ha see table 22). Similarly, the size of most families is a contributing factor to its feasibility [or lack of it]. Many of the families are polygamous with over 92% of the men farmers in both communities having between 2-3 wives in line with Islamic principles. The mean number of children for each family is 8. Most men farmers work averagely between 5-8 hours daily (except on market days and on Friday, which is the Muslim holy day). The number of working hours is higher among women farmers who often spend between 8-12 hours daily on the farm or doing farm-related activity.

Most of the male children (about 88%) and 55% of female children are enrolled in either primary or secondary school, which makes them available for work on farm only on certain days. Labour shortage is a common occurrence especially during peak periods of land preparation, planting, weeding and harvesting. Female labour constitutes the bulk of the family labour as they are involved in planting, weeding, threshing, winnowing, and transportation. Of the respondents, 75% have had between 8-15 years of *fadama* farming experience, while the other 25% have at least 7 years of farming experience. Thus, it can be assumed that all the farmers interviewed are experienced in the farming and management practices of *fadama* areas.

4.2.3 Educational Status of Respondents

The level of literacy among the farmers in Karshi is very low with only a handful of them able to read and write in English. As shown below (table 9), 61.7% of the farmers did not have any formal education while only 23.4 have had primary school education. None of the respondents had post-secondary school education. In Baddeeggi, on the other hand, 33% had no formal education while 47.6% had primary school education with the remaining 19% having some form of formal education beyond primary school. The level of formal education is, therefore, higher in Baddeeggi than in Karshi. The reason for this is the well-established status of Baddeeggi as a major farming and trading centre with a significant government presence.

However, 86% of the respondents in both communities have Qur'anic education which is mandatory for children between the ages of 5-18 in most Muslim households. Some of the respondents are able to read and write Arabic but cannot read nor write in English.

	Karshi			Baddeggi	
		<i>Frequency</i>	<i>Percentage</i>	<i>Frequency</i>	<i>per cent</i>
Education	No formal education	29	61.7	7	33.3
	Up to Primary School	11	23.4	10	47.6
	Up to secondary sch.	7	14.9	4	19.0
	Total	47	100.0	21	100.0

Table 9: Level of education, risk awareness and use of protective clothing among Karshi farmers

4.2.4 Sources of Income of Respondents

The majority of the respondents in Karshi (74.5%) have agriculture (crop and animal husbandry) as their only source of income. The other 25.5%, in addition to farming (usually in a reduced scale than the previous group), are involved in other off-farm activities. In Baddeggi, 71.4% of the respondents depend exclusively on crop and livestock production for their income, while 28.6% depend on other off farm activities, in addition to agriculture (table 10). Off farm income sources include trading and crafts such as mat weaving, carpentry and building. Most of the respondents in both Karshi and Baddeggi (75.6%) are involved in both rain-fed agriculture and recession farming (irrigation). Thus the practice of trade or non-farming income-generating activities is present among *fadama* users. They usually take advantage of specific opportunities available to them either due to its functional or market value. These practices are not fixed but change over time. For instance, road construction through Karshi village means that many women are involved in the trade, mainly of cooked food or local brews, to road workers. Similarly, some men work as manual labourers in construction either in the city or surrounding villages during agricultural off-peak seasons. Other activities carried out alongside agriculture include basic jobs like that of the village butcher, barber or prayer leaders. This confirms research that smallholders are involved in off-farm and/or non-farm employment (Ellis, 2000).

Savings (*adashe* in Hausa) is a common practice among the farmers in Karshi and involves financial cooperation among friends, cooperatives, colleagues and trading partners. According to Woolcock (1998) *adashe* is “a spontaneous ‘bottom-up’ group formation, initiated and sustained by members themselves in response to their isolation from orthodox commercial banks” (p. 183).

	Karshi			Baddeggi	
		<i>Frequency</i>	<i>Percentage</i>	<i>Frequency</i>	<i>per cent</i>
Income	Farming/livestock	35	74.5	15	71.4
	Farming with other	12	25.5	6	28.6
	Total	47	100.0	21	100.0

Table 10: Sources of income of respondents

The general gross income of the farmers at the end of each farming season was moderately high (table 11). In Karshi, the highest category of farmers (62.5%) earn between NGN50, 000-NGN100, 000 while 22.9% (mostly those who own between 2-4Ha) earn above NGN100, 000. Only 12.5% of the respondents earn NGN50, 000 or less. In Baddeeggi, the majority of the respondents (57.1%) earn more than NGN100, 000, 28.6% earn between NGN50, 000-100,000 and 14.3% earn less than NGN50, 000. The higher income among Baddeeggi farmers is related to their farm size, proximity to a river (hence water availability) and the research institute (The National Cereal Institute) with the fringe benefits it offers by way of agricultural extension.

	Karshi			Baddeeggi	
		Frequency	Percentage	Frequency	per cent
Income (By category)	NGN50,000 & Below	6	12.5	3	14.3
	NGN50,000-100,000	30	63.8	6	28.6
	Above NGN100,000	11	23.4	12	57.1
	Total	47	97.9	21	100.0
	Missing system	1	2.1		

Table 11: Income by categories

Much of the income is invested on meeting social pressures especially on health and the education of their children. Due to poor storage and loss during harvest, the income of the farmers is negatively affected.

4.2.5 Methods of Land Acquisition

The method of land acquisition among the respondents in Karshi indicated the following: majority of the (female) respondents (57.4%) acquire land either from husband or from family. 33.4% acquire land by inheritance while the remaining 8.5% get their land either by borrowing or pledge. In Baddeeggi, majority of the respondents (85.7%) acquire their land through inheritance with the remaining 14.3% (the female respondents) acquiring theirs from their husbands.

	Karshi			Baddeeggi	
		Frequency	Percentage	Frequency	per cent
Means of land ownership	From husband/family	27	56.2	3	14.3
	Land from inheritance	16	33.3	18	85.7
	Borrowing/pledge	4	8.3	0	.0
	Total	47	97.9	21	100.0

Table 12: Means of land ownership in Karshi and Baddeeggi

This can be explained by the fact that the majority of the farmers were women who, culturally, are not allowed to own their own land; neither can they inherit land. In general, a combination of cultural reasons and the nature of the tenure system in Nigeria makes land acquisition [even for

men] difficult outside one's place of ethnic origin (Abdullahi, 1981). Women are allowed to work on land owned by their husband or father. The majority of the women respondents cannot therefore, have long-term plans because they do not own land, which is an important resource not only for subsistence but also as security for credit and means for access to other credits (Acati, 1983). The land tenure system in the two areas was identified by some respondents as a constraint to food production. This is discussed subsequently under agricultural constraints in the study area. Suffice it to say that there is a dual tenure system in Nigeria (traditional tenure and formal state tenure) and despite the existence of a Land Use Decree, the relationship between the two has not been formalized and traditional tenure system still takes precedence over state tenure in many parts of rural Nigeria.

4.2.6 Access to Extension Services

Majority of the respondents (72.3%) in Karshi have no contact at all with extension services; while 27.7% do (table 13). Thus, a sizeable number of the respondents do not benefit from productive impact points. This is not difficult to understand considering that only two (2) extension workers are stationed in Karshi village. They are, therefore, unable to reach out to the more than 1,545 farmers even if they wanted to (figure from NFDO/PCU, 2005).

	Karshi			Baddegi	
		<i>Frequency</i>	<i>Percentage</i>	<i>Frequency</i>	<i>per cent</i>
Contact with extension	Yes	13	27.1	15	71.4
	No	34	70.8	6	28.6
	Total	47	97.9	21	100.0

Table 13: Contact with extension officer

In Baddegi, on the other hand, 71.4% have access to extension services while 28.6% do not. This high rate of contact with extension workers is as a result of proximity to the National Cereals Research Institute in Baddegi which operates a number of farms in the area and extends services and resources to the farmers on a regular basis.

4.2.7 A Characterization of Smallholders in Karshi and Baddegi

Whereas throughout this thesis reference is made to 'traditional' *fadama* farming systems/farmers, this is done to distinguish between indigenous farming practices (which are themselves not static) and practices typical of industrial/conventional agriculture – i.e. mechanization, monocropping and pesticides use among others. The farmers in both Karshi and Baddegi straddle the line between 'traditional' and 'modern/conventional' agriculture. For instance, whereas indigenous practices of resource management abound in both communities, so also do practices characteristic of

conventional agriculture. *Fadama* users are not only amenable to external inputs use, they are also constantly revising the corpus of inherited traditional knowledge to incorporate new ideas. Thus, what is inherited and passed along from father to son and mother to daughter is often dialectically assessed to ascertain its desirability and applicability. As demonstrated by Richards (1989), African agriculture is both about a fixed or predefined plan or system as it is about an unfolding improvisation. In several cases, however, farmers retain elements of indigenous practices even when not immediately in use as points of reference. These are passed along in folklores, stories and songs. Also, the interaction of farmers with the market, the structures of government and modern tools (e.g. transistor radios, cell phones, fuel pumps, etc.) means that they deserve a different categorization beyond the simple traditional-modern dichotomy.

4.2.8 Polygamy, Class and Competition in Karshi and Baddegi

The size of a man's land in the two communities is closely linked to his ability to produce more and invariably, this places him well above other members of the community. As indicated above, the bulk of the farmers with more than 1ha of land are men as women almost exclusively cultivated between 0.2-1ha of land. Polygamous families are able to mobilize and take advantage of the bigger labour pool available to them and hence are able to produce more. Also, the few more successful farmers can hire outside labour which often consisted of individuals (mainly single men) and families with insufficient land. Those who do not work as paid labourers are often engaged in off-farm activities and artisanship both around the two communities and in the nearby cities of Abuja and Bida. Thus, through a combination of farm and off-farm activities, the people of Karshi and Baddegi are able to manage their poverty. If there is competition, it is not apparent. Younger single men did not seem keen on taking up full-time farming for what they consider to be the absence of 'incentives'. Similarly, class formation and differentiation was not visible mainly due to the influence of Islam which is critical of economic competition, class struggle and materialism.

4.3 GT Analysis: Stages of Coding

The interest in the first interview was general aimed at finding out what the *fadama* farmers were involved in and how they carried out their farming practices. In other words, their farming situation and the manner in which they manage that situation were explored. Therefore, the participants' initial responses were important for the categories that they suggested. Subsequent interviews/observations were then coded with the first interview/observation and emerging theory in mind. This is the process of constant comparison, i.e. initially comparing data set to data set; later comparing data set to theory (fig 10).

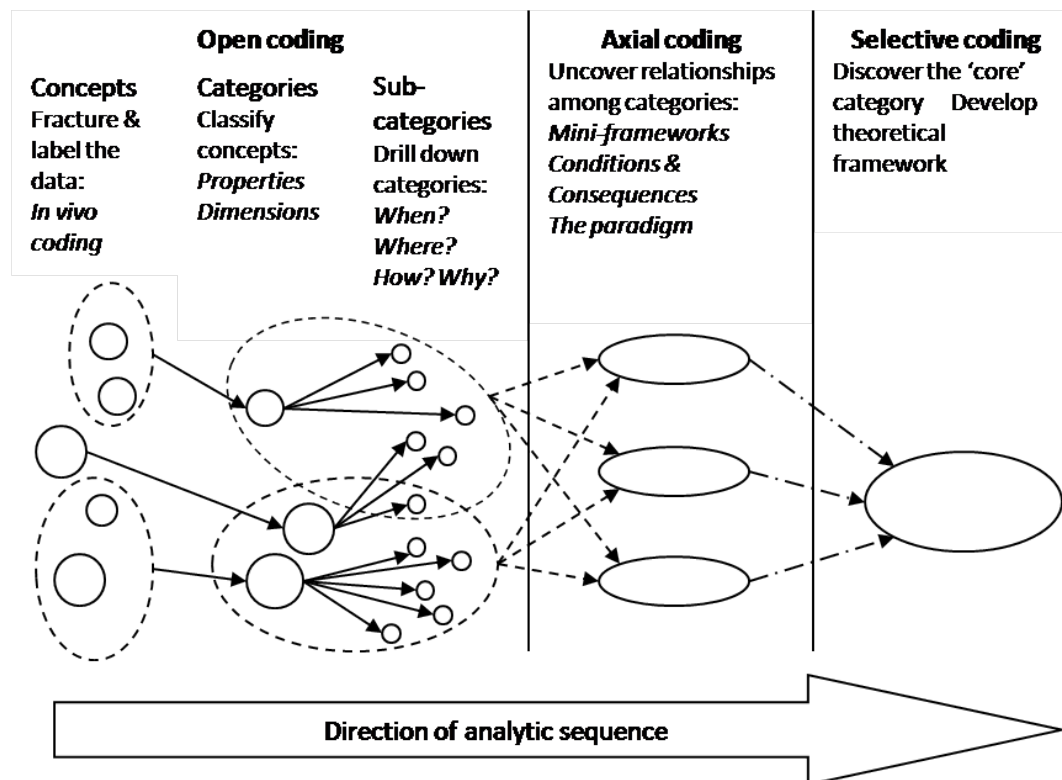


Figure 10: The grounded theory analytic process
Source: Adapted from (adapted from Harwood, 2002a, p. 76)

In this research, 'key point' analysis was used rather than microanalysis for the reason that it saves time and energy and reduces confusion associated with microanalysis (i.e. word-by-word and line-by-line). The points regarded as important to the investigation were identified in the interview transcripts and field notes, noted down on a separate paper and given an identifier (P1, P2, and so on where 'P' indicates 'key point') attributed sequentially starting at the first interview and continuing through subsequent interviews. These identifiers were distinguished with a suffix X, Y or Z to differentiate key points made longitudinally in subsequent interviews.

This is the first level coding and the purpose is to name, categorize, and describe the practice of *fadama* agriculture (based on interviews and field observations). The basic question in this stage of coding is, “what is being referenced here?”

Table 14: Key points and codes from the data in Karshi (X)

ID	Key Point	Codes
Px1	Soil profiling on the basis of colour (<i>launi</i>), moisture content (<i>lema</i>), texture, nutrient value	indigenous soil management indigenous knowledge (IK)
Px2	Use of wells (<i>rijiya</i>), washbowls, and tube wells to access underground water (<i>roman kasa</i>) especially in dry season Different irrigation for different soils/crops	indigenous water management IK risk management (water loss) energy conservation
Px3	Pest control through cropping patterns: crop rotation, mixed cropping, ploughing, ridging	cultural pest control/IK risk reduction (loss to pest) increase yield
Px4	Use of barns (<i>rumbu</i>) and sheds for storage Preservation through cutting and sun drying (<i>bushewa</i>)	traditional storage/IK agricultural yield
Px5	Use of low-cost shallow tube well technology Construction of irrigation canals to avoid many bends	farmer flexibility technology adoption experimentation energy conservation
Px6	Social functions of agriculture – cultural festivals	agricultural multifunctionality
Px7	Poultry on farms or near farm house – <i>roman kaji</i>	integrated farming risk management
Px8	Destruction of farming areas through construction	modification of <i>fadamas</i> institutional constraint
Px9	Predominance of women in rice farming and various stages of agricultural production – harvesting (<i>qirbi</i>), transporting, processing, etc.	role of women
Px9a	Land ownership restricted to men through inheritance (<i>gado</i>) – a woman cultivate husband’s/father’s land	stereotype against women land constraint
Px10	Crops sold only on market days (once in four days – <i>ranan kasuma</i>) – usually sold to marketers from the city	market constrain
Px11	Lack of access to credit schemes, loans (<i>bashi</i>)	financial constrain
Px12	Prevalence of pests/disease (<i>kwan</i>): rodents/birds (<i>bera/ tsuntsaye</i>) Use of various types of insecticide to control pests	insecticide use risk reduction
Px12a	Due to insufficient supply of inputs and cost, most farmers never meet the recommended doses for chemicals	low agrochemical doses
Px13	Set of methods for soil improvement: land preparation – use of plant and animal residues, organic manure (<i>taki</i>), composting (<i>rubawa</i>)	indigenous soil management methods to increase yield IK
Px14	Extensive use of NPK and urea	fertilizer consumption soil fertility constraint
Px15	Work on farm done by families and/or cooperatives (<i>qaiya</i>)	labour
Px16	Prevalence of fish ponds (<i>taf/kin kiji</i>) on farms	integrated farming

Px17	Irrigation on small plots using low level technology (<i>fasaha</i>) – farmer managed	small-scale irrigation indigenous water management/IK experimentation with Chinese technology
Px18	Riverside cropping, water channelling, water furrows, water canals, use of <i>shaduf</i>	indigenous water management/IK
Px19	Organic manure (<i>taki</i>) having longer lasting effect & cost effective	indigenous knowledge/IK
Px20	Hybrid seed (<i>irin zamani</i>) use is limited among <i>fadama</i> users Openness to new seeds	use of hybrid seeds risk management - diversification
Px21	Prevalence of <i>Striga</i>	parasitic weeds constraint
Px21a	Control of <i>Striga</i>	herbicide prevalence
Px22	Pest control through use of barriers, scarecrows (<i>botorami</i>)	cultural pest control
Px23	Use of simple tools – manufactured on farms	energy conservation
Px24	Use of cow dung (<i>kashin shani</i>)& poultry droppings (<i>kashin kaji</i>) due to shortage of fertilizer	fall-back on organic fertilizer
Px25	Not used for cooking or the making of local brew (<i>kunun zaki</i> or <i>burkutu</i>) – poor taste	hybrid seeds scepticism
Px25a	Planting of hybrid seeds because they mature early and can be sold	economic consideration flexibility/risk management experimentation
Px26	<i>Fadama</i> users admit to tedium involved in farming – mostly land preparation and weeding	drudgery labour
Px26a	Perception that simple tools can make a difference – such as hand operated tractors	simple technology drudgery flexibility
Px27	Control of pests in storage using chemicals	insecticide use
Px28	Cropping pattern: use of cover crops and green manure, crop rotation, mixed cropping	indigenous soil management/IK methods of increasing yield
Px29	The keeping of short cycle animals – goats, sheep and a few cows	integrated farming
Px30	Hybrid seeds perform only with fertilizer and herbicide Preference for local seeds	attitude/use of hybrid seeds constrain fall-back on local methods/varieties
Px31	Use of barns (<i>rumbu</i>), drying (<i>bushewa</i>)	traditional storage/IK
Px32	Difficulty in getting input due to bureaucracy and corruption involved	inaccessibility of input
Px33	The practice of testing new seeds/technology on smaller plots	experimentation flexibility/risk reduction
Px34	Farmers not happy with treatment and neglect by government	dissatisfaction with conception institutional constraint
Px35	Use of simple and non-inverting tools (<i>fartanya, garma</i>) for minimum soil disturbance	indigenous soil management/IK

Px36	Poor roads, social and economic facilities	poor infrastructure
Px37	Willingness to expand – shortage of labour Where you are born is your home – the soil is where your heart is	labour demand/drudgery meaning through farming
Px38	Dissatisfaction with fertilizer availability and distribution	fertilizer constraint
Px39	Farming is all I know – I do it very well and my whole life revolves around it	self-knowledge/confidence meaning through farming
Px40	Use of residual soil moisture for recession farming (<i>noman rani</i>)	indigenous water management/IK
Px41	High cost of herbicide/inaccessibility Fall-back on organic weed management	low agrochemical doses cost– constraint fall-back on local methods/varieties
Px42	Environmental function of agriculture – planting of certain plants to curb erosion, serve as windbreakers, or beautify	agricultural multifunctionality
Px43	My whole life was lived working these fields – reduced yield – rainfall	meaning through farming constrain of agricultural seasonality
Px44	Crops from hybrid seeds perform less or worse than local seeds if not used with fertilizer/herbicide Use of local varieties alongside hybrid varieties	attitude/scepticism towards hybrid seeds consideration for risk minimization
Px45	Altering planting & harvesting times for pest control	cultural pest control adaptation/risk management
Px46	Sacred relationship with land	agricultural multifunctionality meaning through farming
Px47	Storage in barns often not sufficient and restricted to cereals	storage constrain
Px48	Efficient disposal of surface water	indigenous soil management/IK energy conservation
Px49	Recognition that production falls below optimum due to constraints – e.g. erratic rainfall, drought, poor income, lack of inputs	recognition of limitation constraints to <i>fadama</i> agriculture
Px50	Crop loss during harvesting, processing, storage – most crops are seasonal	harvest and post-harvest losses harvesting constraint
Px51	Recession farming (<i>noman rani</i>)	maximum land use economic sustainability adaptability/risk management supplement yield from rain-fed farming
Px52	Religion (Islam) a major influence on labour division and gender considerations – what women are allowed to do or not	religion socio-religious value of farming gender/power & religion
Px53	High cost of fertilizer Increased use of organic fertilizer	fertilizer constraint fall back on organic fertilizer
Px54	Cultural customs restrict women (<i>al'ada</i>): limited access to land	gender and power
Px55	Storage: use of heat to maintain temperature, keep off weevils in storage barns	cultural pest control/IK
Px56	The keeping of grasscutters (<i>gafiya</i>)	integrated farming flexibility/adaptation risk management
Px57	Insufficient knowledge of where to acquire improved seeds	hybrid seeds input constraint
Px58	Customary tenure system – limits women and foreigners' access to land	land constraint
Px59	Indigenous tillage practices: ridge planting (<i>kumya</i>)	indigenous soil management/IK

		labour management
Px60	Farmers berate government officials for taking what is meant for them	apprehension of government
Px61	Promotion of hybrid seeds by extension workers – hybrid seeds named after extension workers	institutional support for agrochemicals
Px62	General consensus among men that giving women rights will make them more powerful than men	gender and power
Px63	Fire incidence in barns	harvest loss storage constraint
Px64	Willingness to adopt farming practices that are practicable and beneficial – and easy to use (e.g. hand operated tractors, simple cassava processors)	farmer flexibility technology adoption
Px65	<i>Fadama</i> users agree they are capable of meeting food needs if supported	grassroots support/people issue
Px66	Widespread use of whatever fertilizer is available – which is often very little considering cost and inaccessibility	Fertilizer use fertilizer use below recommended level – not intensive
Px67	Agriculture seen as a cultural heritage	agricultural multifunctionality meaning through farming
Px68	Inability to read instructions on chemical containers – storing of chemicals in living/sleeping spaces	Inappropriate handling of agrochemicals
Px69	Medicinal extracts for pest/disease control	cultural pest control
Px70	All respondents didn't know of any negative effects of fertilizer use	Awareness (lack of it) of agrochemicals negative effects
Px70a	Limited use of protective clothing, indiscriminate disposal of used up chemical containers or use to store water/food	Inappropriate handling of agrochemicals
Px71	Intercropping : cereals with legumes; maize and melon; cassava and maize; banana and cowpea Farmers produce enough food to feed their family and sell	maximum land use risk management energy/labour conservation method of increasing yield economic sustainability/yield
Px72	Knowledge of climatic changes and moisture conditions	knowledge of biophysical conditions/IK agricultural seasonality-constraint
Px73	Late arrival of fertilizer	fertilizer constraint
Px74	Knowledge passed from parents to children	knowledge transfer
Px75	Women's access to land dependent on marriage and 'good' conduct	gender and power
Px76	Surfacing of canals and furrows (<i>kwarin kunya</i>) to reduce water loss	indigenous water management/IK risk management
Px77	Reluctance to disclose plants used in medicinal solutions	secrecy apprehension
Px78	Reported discomforts, nausea, body and eye itching and even death after chemical use	agrochemical effect
Px79	Social functions based on agriculture – festivals	socio-cultural value of agriculture
Px80	Unaware of the effect of wholesale hybrid seed adoption	awareness (lack of it) of negative

		agrochemicals effect
Px81	Weeding, burning, burial of plant residues	soil management/IK risk management cultural pest control
Px82	Risk management prompts choice of farming practices – reduce risk due to water loss, loss to pests, erratic rains	IK risk management
Px83	Inability to afford inputs Fall-back on available locally produced inputs	Financial/input constrain fall-back on local methods/varieties
Px84	Few extension workers for hundreds of farmers	extension constrain

The next step was to group the **codes** with a common theme together. Codes grouped together have commonality and the emerging group is called a **concept**. These concepts are then grouped together to form **category**, which is a theme or variable that makes sense of what the interviewee has said. It is from the concepts and categories that a theory emerges. Thus, the analysis proceeded by looking for new key points with the aim of comparing them with the concepts and categories already established. This process is called *substantiation* and leads to a substantive theory (Glaser and Strauss, 1967).

4.3.1 Emergence of Concepts

The next step in the coding process to group similar codes from above set of data. They are then compared for commonality and *codes with commonality* were then grouped together to form *concepts*.

Table 15: Emergence of concepts from the codes in Karshi (x)

Indigenous soil management: Px1, Px13, Px28, Px35, Px48, Px59
Indigenous water management: Px2, Px17, Px40, Px76
Cultural pest management: Px3, Px22, Px45, Px55, Px69, Px81
Traditional storage methods: Px4, Px31
Integrated farming: Px7, Px29, Px56
Appreciable yield/economic sustainability: Px3, Px13, Px28, Px51, Px71
Indigenous knowledge: Px1, Px2, Px3, Px4, Px13, Px17, Px18, Px19, Px28, Px30, Px31, Px33, Px35, Px40, Px48, Px55, Px59, Px72, Px76, Px81, Px82
Self-perception: Px34, Px39, Px49
Energy conservation: Px2, Px5, Px23, Px48, Px71
Experimentation: Px5, Px17, Px25a, Px30
Extensive agrochemical use/effects: Px12, Px14, Px21a, Px27, Px78
Low agrochemical doses: Px12, Px14, Px21a, Px27, Px12a, Px41, Px66
Use of and perception of hybrid seeds: Px20, Px25, Px30, Px44, Px57, Px61
Fall-back on traditional methods: Px24, Px30, Px41, Px83

Perception of government: Px8, Px60
Flexibility/adaptation/diversification: Px5, Px20, Px26a, Px45, Px51, Px56, Px64
Risk management: Px2, Px7, Px12, Px25a, Px33, Px44, Px45, Px51, Px56, Px71, Px76, Px81, Px82
Social value of agriculture/meaning/multiple roles of agriculture: Px37, Px39, Px42, Px43, Px46, Px51, Px67, Px79
Role of women/stereotype against women: Px9, Px9a, Px52
Gender and power: Px9, Px54, Px62, Px75
Inadequate knowledge of/poor handling of agrochemical effects: Px12, Px14, Px21a, Px27, Px68, Px70a, Px70, Px78, Px80
Constraints to <i>fadama</i> agriculture: Px9a, Px10, Px11, Px14, Px15, Px21, Px26, Px26a, Px30, Px32, Px36, Px37, Px38, Px41, Px43, Px47, Px49, Px50, Px53, Px58, Px63, Px73, Px83, Px84
Reluctance in knowledge sharing: Px77

4.3.2 Categories

By applying the constant comparison technique to each concept in turn, common themes were looked for and identified amongst the concepts. These further commonalities found were then grouped together to form **categories**. This is illustrated below (table 16):

Table 16: Emergence of categories from the concepts in the data from Karshi (x)

TRADITIONAL <i>FADAMA</i> RESOURCES MANAGEMENT Indigenous soil management: Px1, Px13, Px28, Px35, Px48, Px59 Indigenous water management: Px2, Px17, Px40, Px76 Cultural pest management: Px3, Px22, Px45, Px55, Px69, Px81 Traditional storage methods: Px4, Px31 Energy conservation: Px2, Px5, Px23, Px48, Px71 Integrated farming: Px7, Px29, Px56 Appreciable yield/economic sustainability: Px3, Px13, Px28, Px51, Px71
RELIANCE ON INDIGENOUS KNOWLEDGE Indigenous knowledge: Px19, Px33, Px59, Px72 Fall-back on traditional methods: Px24, Px30, Px41, Px83 Fall-back on traditional methods: Px24, Px30, Px41, Px83 Experimentation: Px5, Px17, Px25a, Px30 Reluctance in knowledge sharing: Px77
RISK MANAGEMENT / <i>RAGEN ASARA</i> Risk management: Px2, Px7, Px12, Px25a, Px33, Px44, Px45, Px51, Px56, Px71, Px76, Px81, Px82 Flexibility/adaptation/diversification: Px5, Px20, Px26a, Px45, Px51, Px56, Px64 Fall-back on traditional methods: Px24, Px30, Px41, Px83
EXTERNAL INPUTS Extensive agrochemical use/effects: Px12, Px14, Px21a, Px27, Px78

Inadequate knowledge of/poor handling of agrochemical effects: Px12, Px14, Px21a, Px27, Px68, Px70a, Px70, Px78, Px80 Use of and perception of hybrid seeds: Px20, Px25, Px30, Px44, Px57, Px61
GENDER AND POWER IN <i>FADAMA</i> AGRICULTURE Role of women/stereotype against women: Px9, Px9a Gender and power: Px9, Px54, Px62, Px75
SOCIO-CULTURAL VALUE OF AGRICULTURE/MULTIPLE ROLES OF AGRICULTURE Socio-Cultural value of agriculture/meaning/multifunctionality: Px37, Px39, Px42, Px43, Px46, Px51, Px67, Px79
FARMERS' PERCEPTION OF SELF AND OTHERS Self-perception: Px34, Px39, Px49 Perception of government: Px8, Px60
CONSTRAINTS IN <i>FADAMA</i> AGRICULTURE Constraints to <i>fadama</i> agriculture: Px9a, Px10, Px11, Px14, Px15, Px21, Px26, Px26a, Px30, Px32, Px36, Px37, Px38, Px41, Px43, Px47, Px49, Px50, Px53, Px58, Px63, Px73, Px83, Px84

4.3.3 Emergence of Categories from Baddegi (y)

The second study site was Baddegi, a community in a different state in Nigeria, but also involved in *fadama* agriculture. New key points from Baddegi case study were subsequently compared with the concepts and categories already established from Karshi case study (above) for substantiation (table 17).

Table 17: Emergence of categories from the concepts in the data from Baddegi (y)

TRADITIONAL <i>FADAMA</i> RESOURCES MANAGEMENT Indigenous soil management: Py3, Py8, Py8a, Py12 Indigenous water management: Py1, Py4, Py8, Py16 Cultural pest management: Py5, Py8, Py9 Traditional storage methods: Py6, Py13 Energy conservation: Py4, Py6, Py8, Py16 Integrated farming: Py3, Py4 Higher yield/economic sustainability: Py7, Py14, Py17
RELIANCE ON INDIGENOUS KNOWLEDGE Indigenous knowledge: Py1, Py3, Py8, Py20 Fall-back on traditional methods: Py3, Py4, Py8, Py20 Experimentation: Py2, Py15, Py18
RISK MANAGEMENT/<i>RAGEN ASARA</i> Risk management: Py2, Py3, Py8, Py20, Py22, Py31 Flexibility in technology adoption/modification: Py6, Py10 Fall-back on traditional methods: Py3, Py4, Py8, Py7
EXTERNAL INPUTS Extensive agrochemical use/effects: Py7, Py10, 11, Py13

Inadequate knowledge of/poor handling of agrochemical effects: P _Y 7, P _Y 10, 11, P _Y 13 Use of and perception of hybrid seeds: P _Y 15, P _Y 18, P _Y 26
GENDER AND POWER IN <i>FADAMA</i> AGRICULTURE Role of women/stereotype against women: P _Y 19, P _Y 24, P _Y 31 Gender and power: P _Y 19a, P _Y 28
SOCIO-CULTURAL VALUE OF AGRICULTURE/MULTIPLE ROLES OF AGRICULTURE Socio-Cultural value of agriculture/meaning/multifunctionality: P _Y 3a, P _Y 14, P _Y 27, P _Y 29
FARMERS' PERCEPTION OF SELF AND 'OTHERS' Self-perception: P _Y 7a, P _Y 14 Perception of government: P _Y 3, P _Y 9, P _Y 11
CONSTRAINS IN <i>FADAMA</i> AGRICULTURE Difficulties/constrains in <i>fadama</i> agriculture: P _Y 7, P _Y 9, P _Y 11a, P _Y 20

Most of the categories from the Karshi case study (x) were supported by findings in Baddeggi. The following categories: '*fadama* farming as sustainable in resource management' 'reliance on indigenous knowledge systems' and the category of 'external inputs' were supported. However, the category of 'gender and power in *fadama* agriculture' differed from that in Karshi as women were not heavily involved in *fadama* agriculture in Baddeggi due to religious (Islamic) reasons. There was a significantly different interpretation of religious rules from that in Karshi. All other concepts were equally supported except that of 'reluctance in knowledge' sharing'. No other new concepts/categories emerged.

4.3.4 Emergence of Categories from Study Group (z)

The third study group comprised of respondents from government agencies, institutions of global governance (e.g. the WB), and the academia. These respondents are influential in policy making that shapes the kind of support that *fadama* users get in their agricultural production. Key points and codes that emerged in the case study are summarized below (table 18), as well as the emerging concepts and categories (table 19 & 20):

Table 18: Emergence of key points and codes from case study z

ID	Key Point	Code
Pz1	Smallholders considered as peasants whose traditional methods of crop and animal production are out-dated	perception
Pz2	The challenge in Nigeria is to increase productivity to meet food security This can only be done through improved inputs	productivity mechanization agrochemicals
Pz3	Emphasis on modern farming techniques	modernization
Pz4	'Peasants' can be the driving force in achieving food security in Nigeria	importance of peasants
Pz5	Agriculture has to become more productive so that 'peasant' farmers can earn more through	commercial agriculture
Pz6	Higher levels of technology	technology
Pz7	The main constrain of smallholders is reliance on family labour	drudgery technology
Pz7	Need for more inputs	agrochemicals
Pz8	Larger amount of arable land for 'peasant' farmers for increased production	commercial agriculture productivity
Pz9	scientific progress	mechanization
Pz10	Most of food produced by 'peasants' is wasted in harvest and post-harvest circumstances. This can be reduced with technology	technology productivity
Pz11	Cheap and affordable food – profitable for the farmers	profitability
Pz12	Small-scale farmers cannot feed the nation in their present situation	perception
Pz13	Depleted soil and other biophysical constrains make it necessary to have sufficient fertilizer and herbicides (against Striga)	agrochemicals
Pz14	Small-scale farmers face problems of lack of sufficient access to inputs needed to boost their productivity They have largely been neglected	constraints: inputs, financial, capacity, extension, etc. institutional constraint
Pz15	Agricultural machinery for labour efficiency	mechanization
Pz16	Genetic technology	technology
Pz17	Faster and more effective food production is only possible with sufficient inputs	agrochemicals

Table 19: Emergence of concepts from the codes in case study (z)

Perception of smallholders: P _Z 1, P _Z 4, P _Z 12
Problem of smallholder productivity: P _Z 2, P _Z 8, P _Z 10
The need for agricultural mechanization: P _Z 2, P _Z 9, P _Z 15
Modernizing smallholders: P _Z 2
The need for higher technologies: P _Z 6, P _Z 7, P _Z 10, P _Z 16
Commercializing smallholder farmers: P _Z 5, P _Z 8
The need for more agrochemicals: P _Z 2, P _Z 7, P _Z 13, P _Z 17
Importance of smallholders in food security: P _Z 4
Constraining factors for smallholders: P _Z 7, P _Z 14

Table 20: Emergence of categories from the concepts in case study (z)

PROBLEM OF SMALLHOLDER PRODUCTIVITY Problem of smallholder productivity: P _Z 2, P _Z 8, P _Z 10 Constraining factors for smallholders: P _Z 7, P _Z 14
EXTERNAL INPUTS NECESSARY FOR INCREASED AGRICULTURAL PRODUCTIVITY The need for agricultural mechanization: P _Z 2, P _Z 9, P _Z 15 Modernizing smallholders: P _Z 2 The need for higher technologies: P _Z 6, P _Z 7, P _Z 10, P _Z 16 Commercializing smallholder farmers: P _Z 5, P _Z 8 The need for more agrochemicals: P _Z 2, P _Z 7, P _Z 13, P _Z 17
PERCEPTION OF SMALLHOLDERS BY ‘OTHERS’ Perception of smallholders: P _Z 1, P _Z 4, P _Z 12

4.3.5 Theoretical Codes

These new categories are then integrated into the list of emerging categories already identified in the two previous case studies (X and Y). The main categories identified are linked together to establish relationship, i.e. a theory (fig 11). The categories from case study x and y were: *traditional fadama agriculture is efficient in resource management; fadama agriculture relies on indigenous knowledge; fadama agriculture results in appreciable but not optimum yield; fadama agriculture is primarily about risk reduction; prevalence of external inputs use in fadama areas but not intensive; gender and power are important in fadama agriculture; fadama agriculture plays multiple socio-cultural/environmental roles; fadama agriculture is constrained by many complex factors.* The categories that emerged from case study z were: *problems of smallholder productivity; external inputs necessary for increased productivity and perception of smallholders by ‘others’.* The connections between these categories are fully discussed in the sections below.

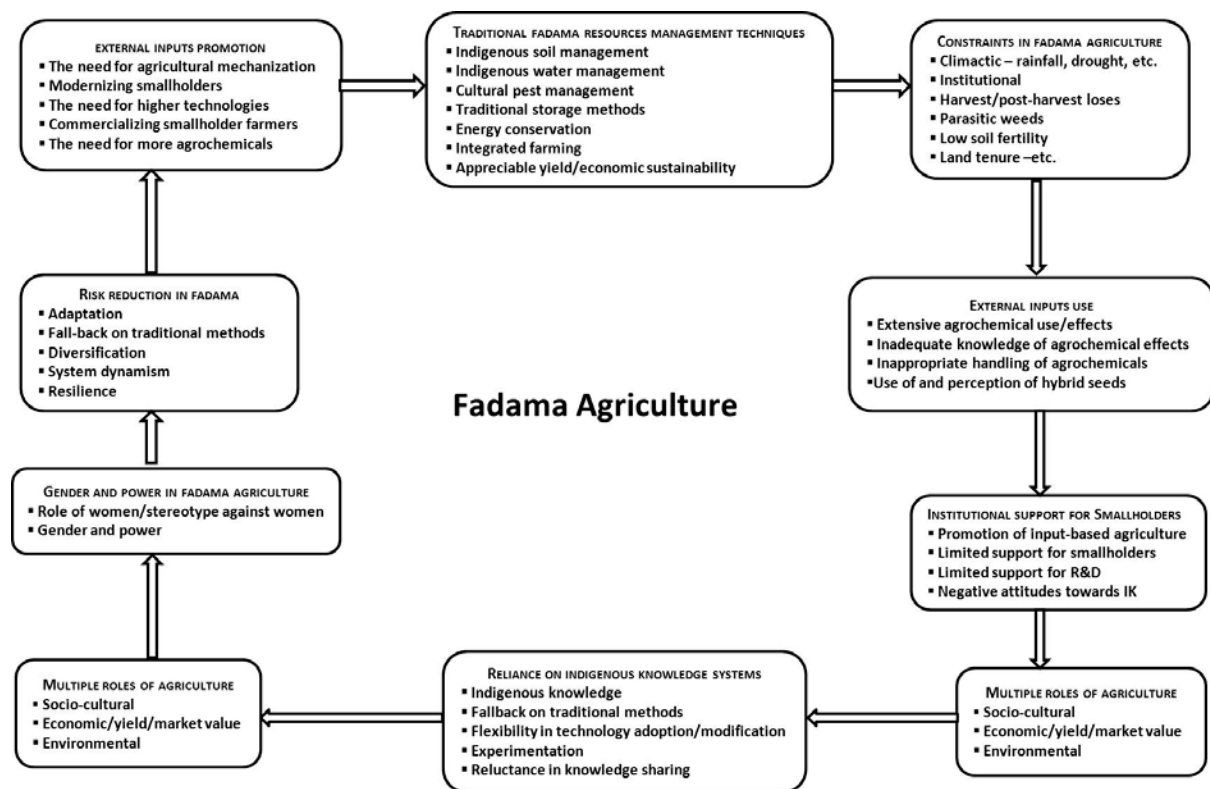


Figure 11: Emergent categories derived from grounded theory analysis of data in the case study on *fadama* agriculture in Karshi and Baddeggi, 2008

4.4 Relating and Integrating Core Categories

By linking the categories and investigating the connections between concepts a theory emerges. The core categories that emerged from the analysis above can be summarized thus: *fadama* farming relies on a series of traditional resource management strategies. Also, *fadama* farmers are flexible and willing to adapt to changing times and blend available technology with traditional methods in ways that are sustainable. The average yield of farmers for most crops is reasonably good but far below the possible optimum. The use of agrochemicals was found to be extensive but not intensive as applied doses often fell short of the recommended levels. However, the threat that agrochemicals pose to the delicate *fadama* ecosystem and its users were real and observable. The resurgence of a series of traditional management techniques and practices is partly due to the high cost of external inputs, neglect of smallholders in mainstream agricultural planning and environmental considerations. Despite the potential of traditional agriculture for increased productivity if properly managed, institutional, socio-political and cultural factors constrain *fadama* users. Results from the fieldwork reiterate a negative bias towards smallholders. Finally, women play significant role of in agricultural production in a society that generally sees them as second-class citizens. These findings are discussed in details below.

4.5 Traditional Resources Management Techniques in Karshi and Baddeggi

4.5.1 Traditional Soil Management in Karshi and Baddeggi

The traditional farming communities of Karshi and Baddeggi have an almost reverential approach to land which is the main source of their livelihoods - land. The practice of soil cultivation is carefully carried out based on an extensive knowledge of soil type, condition and even location as explained by a farmer in Karshi:

Some lands and farms are near flowing water/ river/ stream or somewhere on their course. These rivers deposit nutrients from year to year. For such lands, they are always fertile and good for agriculture and so you don't need any chemicals or fertilizer.

Soil is carefully profiled based on attributes such as colour, texture, nutrient value and level of acidity. Based on the soil attributes and the type of implements available to them (mostly hoes, cutlasses and machetes), the farmers decide on what type of crop is best suited for what soil, the acceptable level of moisture ideal for what crop and the time to carry out the actual planting. From accumulated experience and knowledge passed on from generation to generation, the process of soil profiling has become entrenched. For example, a farmer explains the interaction between soil type and the choice of crop planted:

I look out for the texture of the soil. If it is strong [fertile], for example, then groundnut is the ideal crop for that soil. After you have done this for a while you begin to know which soil is ideal for what and what it requires. For example, when the colour of the soil is dark [loamy soil], then you know it is rich and ideal for maize. For groundnut, the soil is not as dark but it is strong [sandy-loamy]. For rice, the best is the one that retains water – it is also dark [clay-loamy soil] – also the heights are not very good for rice.

For many of the rice farmers, the moisture content of the soil and its ability to retain or lose water (*lema*) are important factors in deciding how to go about rice production.

There is a difference between a land that retains a lot of water and moisture – the water remains for a while – that kind of land is good for rice. But it is not good for maize. The best land for soil is one that is moist but which does not retain it for as long as the one for rice.

A broad range of soil management techniques are employed by these farming communities and include among others minimum tillage activities, use of non-inverting implements, use of cover

crops and green manure, crop rotation, mixed cropping, and effective control and disposal of surface water for use on farm.

However, although the traditional method of land preparation through ploughing employed by many farmers in these villages has the benefit of enriching the soil as a result of buried residues, the process of soil inversion and pulverization often also means that the soil is exposed to erosion. Tillage in these two communities depends on soil type, climate, crop type and topography. For instance, tuber crops (e.g. yam and cassava) are usually planted by means of manual mounding/ridging – usually made after harrowing, sub-soiling and furrowing. There is generally no consensus in the literature on what tillage method is suitable for tuber crops like yam (Agbede, 2006).

The farmers in these communities are also knowledgeable about conservation/minimum tillage systems and carry it out in several ways so as to minimize soil erosion, manage water efficiently through improved water infiltration into the soil and the reduction of evaporation, save time and improve soil structure.

Whatever I do as a farmer I have to try and make sure that it does result in loss (asara) for me. I have to make sure that the land will still be strong [fertile] for the next season. But this is becoming difficult every year because the soil is becoming less strong [fertile] and sometimes the rain is not good. So I always struggle to make sure the land is producing by not over-using the soil and water. So whatever method I use will depend on the type of crop I am planting for that season and the strength of the soil.

The practice of ridge planting (*kunya*), where crops are planted on ridges, is a common practice among many of the farmers as a means of controlling water erosion and ensuring water conservation. Similarly, the soil is enriched as a result of buried grass/weeds during ridge preparation. Ridge planting also makes farm operations like weeding, manure application and harvesting easier. The value of ridge planting was explained thus by a farmer in Karshi:

The crops made on ridges/heaps usually perform better than those on flat ground. The first reason is that ridges have buried grass/weeds which serve as manure. Secondly, it allows crops like tuber crops (like yam) to easily penetrate the soil and attain full size and length. Some of my fellow farmers make sure that enough manure is buried in the heaps so that the crop grows well and big.

Most farmers agree that crop yields in ridge planting are higher than those in flat fields due to increased moisture content that ridge planting allows, that is, rainwater is effectively channelled to plants – this is crucial especially in *rain-fed* farming systems like *fadama* farming.

Nutrient cycling is an important way *fadama* farmers use to maintain soil fertility. The use of organic fertilizer (livestock manure, poultry droppings, compound waste, etc.) as means of improving soil fertility is common among the farmers in Karshi and Baddegi. This is despite the fact that chemical fertilizer has gained ascendancy in the past couple of years because its effects seem more immediate than organic fertilizer. Yet, there is the awareness among the farmers that the effects of organic fertilizer on the soil seem more long lasting than those of chemical fertilizer. This is in addition to the fact that it is more cost-effective, non-toxic, and more environmentally sustainable. The most common organic fertilizer employed by the farmers is animal fertilizer – cow manure (*kashin shanu*) and poultry manure (*kashin kaɓa*). A vegetable farmer explained his preference for chicken droppings thus:

If you get the chicken droppings it is really very good. It makes the onions flower fast and you can see the effect in the colour and texture of the leaf. The difference between kashin kaɓa and chemicals is that chemical helps to make the onions bigger but kashin kaɓa improves the quality of the leaf which our people make soup with and also makes the onions taste better.

Manure produced by livestock tethered on farms or in farm houses are mixed with stalks, fodder, wood-ash and cooking waste and returned to the field. Some of the farmers keep poultry or cattle on their farms and harvest the manure for use on the farm. Those who do not keep animals buy from those that do. Often, the manure is packaged in 50Kg bags which cost about N40 a piece. The manure is mixed with the soil at land preparation just before planting. At times, the farmers enter into a beneficial relationship with the Fulani⁸ herdsmen by giving them a portion of their land (usually during the dry season or when they have rotated and that particular land is not in use) for their animals to graze on. The animal droppings become manure which enriches the soil against the next farming season. Thus, nutrients in crop residues are recycled by livestock to produce manure.

In addition to the use of animal-based organic fertilizer, the farmers also use plant-based organic fertilizer such as compost (*rubawa*) which is a rich and versatile source of soil nutrient. Food wastes are usually left on heaps either on the farm or at home to biodegrade. This is often used in addition

⁸ The Fulani are a nomadic people scattered throughout most of West Africa where they established extensive links with other groups and helped in the spread of Islam. The height of the Fulani Empire was between the early 1800s and early 1900s.

to other methods such as grass/plant leaves burying and so forth which add organic matter and nutrients to the soil through their gradual breakdown. This was explained further by a farmer in Baddeggi:

It is common among us rice farmers to leave behind rice stalks on the farm – some burn it – they are then added into the soil. Through burning or leaving crop residues to decay, the strength [quality] of soil fertility is increased.

According to another farmer in Karshi:

In addition to using cow dung and poultry droppings, I also use other traditional methods like grass burying, mulching, etc. Often we deliberately shed off leaves from trees, decompose those and use as manure – usually we do this before planting. The crops do very well in these cases.

Thus soil fertility and structure/texture are simultaneously improved over a long period of time and the risks of pollution are also greatly reduced. The bulk of the farmers display keen awareness on the potency of compost in improving soil quality through improved moisture retention. Wood ash - *toka* (from grass burning or home cooking) is also used to raise soil pH, improve soil structure, and add nutrients (potassium). Occasional addition of household refuse (*taki*) supplemented the natural silt.

There is a general preference for traditional methods of improving the soil among some farmers as this banana farmer explained:

You can apply chemical fertilizer if you want but most of us prefer to rely on the natural fertility of the soil – it is far better than any chemical fertilizer which actually affects the taste of the banana. The residue from the land clearing and the ash from the burning of the bush are enough fertilizers. Actually such a land can last for up to 4 years producing maximum yield and not losing its fertility.

Crop rotation is another sustainable cropping system used by the farmers in Karshi and Baddeggi to protect soil chemistry, control weed and soil erosion, reduce risk of disease and improve soil fertility and crop yield. According to a farmer in Karshi,

Myself and the other farmers never farm cultivate a single crop for many successive seasons. For instance, I cannot plant yam in two successive seasons on the same land – I rotate with maize or guinea corn. This helps me to avoid common yam disease/insects and it is also good for the soil. I think this is true also for many of the rice farmers here – they also rotate with other crops.

Thus, rotation is usually carefully planned to rotate cereals such as maize, sorghum or guinea corn with legumes such as beans, groundnut, and so forth. None of the farmers interviewed in Karshi, for instance, plants the same crop on a given piece of land in two successive seasons as explained above. As many of the farmers cultivate between 1-2 Ha of land, rotation is designed such that the farm is divided into 3-4 sections with each section planted with a different crop. Among other things, rotation reduces cost from the purchase of fertilizer and herbicides. It is also a means of risk management as loss due to the prevalence of pests specific to one crop are controlled.



Ridge planting in Karshi



Low tillage in Baddeggi



Use of crop residues to improve soil fertility in Karshi



Use of decaying weeds for soil fertility in Karshi

4.5.2 Traditional Pest Management in Karshi and Baddeggi

Traditional pest management in Karshi involves a series of actions planned to deal with a particular pest problem and to reduce risk of crop loss. In addition to methods like crop rotation and mixed cropping which serve to reduce the risk of pests and diseases, the farmers also design ways to deal with specific problems such as bird attack on rice fields. These range from the use of simple techniques such as the erection of insect barriers, the use of bells and scarecrows to more advanced ones involving the use of medicinal plants.

Specific cultural methods to control and manage pests Karshi and Baddeggi include the following: altering the time of planting, where farmers plant their crops after the first few rains or towards the end of the rainy season. By planting early or late, the crops avoid one or more developmental phase (for instance, egg laying) of some pests. For instance, early planting is predominantly common among vegetable growers in both Karshi and Baddeggi because the farmers observe fewer incidences of pests early in the season. However, some farmers are cautious about this method especially in light of erratic rains and occasional drought. Such farmers prefer to wait a little longer into the rainy season before planting.

As summarized by Speight (1983), altering time of planting and/or harvesting may help achieve the following: “(a) upset the synchrony between the pests life cycle and its food plant (b) reduce the time available to the pest in which to exploit the crop, or (c) prolong the life of the crop so that it can tolerate or resist damage better than a short lived, fast growing one” (186-188). The efficacy of altering planting/harvest time in pest control has been amply demonstrated in different crops: soybean (Buschman et al., 1981); Barley (Ba-angood and Stewart, 1980); maize (Panwar and Sarup, 1979); sorghum (Rai and Jotwani, 1979); rice (Kiritani, 1979).

Another cultural method of pest control is crop rotation which, in addition to serving as weed control strategy, helps to disrupt the life cycle of pests and crop diseases. The practice and effectiveness of crop rotation by smallholder farmers in the tropics is extensively documented (Christie, 1959; Miller, 1971; Nusbaum and Ferris, 1973; Sethi and Gaur, 1986; Trivedi and Barker, 1986; Brown, 1987; Bridge, 1987; Bridge, 1996; McSorley, 1996). Also, the practice of mixed cropping is used to control pests in the two study communities as explained by a famer in Karshi:

The crops I have here are mainly for utility and having different crops on the same land helps me get little of everything, especially because sometimes one of the crops, say maize, does not perform well, either because of rain or Striga. Also helps to control insects – because some insects that attack rice don't attack maize/beans, they are actually repelled by it.

The use of crop rotation for pest management is especially widespread among male yam farmers in Karshi and Baddegi. The farmers show awareness of the different types of pests/diseases that affect their crops and how a pest that feeds on maize, for instance, does not have any effect on cowpea or rice. By rotating, the incidence of a particular pest is reduced and hence the potential damage it can inflict on the said crop in successive seasons, if left to build up, is minimized. This finding corresponds to research in different root crop growers in different parts of Nigeria who use crop rotation as a means for pest control (Ogundana et al., 1970; Nwakiti and Arene, 1978; Arene, 1980; Nwakiti, 1982).

The use of extracts (*magan*) of medicinal plants such as spear grass (*Imperata cylindrica*), and neem (*Azadirachta indica*) tree, for pest control is prevalent in Karshi and Baddegi. An elderly farmer explained some of the ingredients and process of making medicinal extracts:

Among the main ingredients are the roots of spear grass, the roots of palm tree, the bark/ root of neem tree, and also the vegetative part of koro (wild ginger) (grows by the river bank and also used for mat and traditional fan making). They are put into water and left on the farm for a few weeks until the water turns brownish black and then it is also mixed with the root of a prickly plant we call karara which causes skin irritation. It is also important to mix it with wood ash. This is rubbed on the leaves and planted in the field and this keeps insects and birds away.

Usually, the farmers extract the sap from the vegetative parts of these plants either through boiling or squeezing and use that to make a potent mixture which is then used either to treat seeds before planting or applied in the field to curtail the spread of pests. Research in other parts of Nigeria has shown the benefits (e.g. availability and low toxic effects) of such medicinal plants to resource poor farmers (Umoetok et al., 2009).

The medicinal qualities of *neem* are properly documented among the people and various parts of this plant are used to treat a range of diseases as well as control diverse types of pests, such as root nematodes (Javed et al., 2008; Montes-Molina et al., 2008; Islam et al., 2009; Ntalli et al., 2009). When used as soil amendment, *neem* enriches the soil and lowers the risk of nitrogen loss by inhibiting nitrification (Mohanty et al., 2008). Similarly, the medicinal qualities of spear grass are known to include astringent, febrifuge, diuretic, tonic and styptic action. It is also used as soil cover and to prevent erosion (Duke and Ayensu, 1985; Yeung, 1985; Chopra et al., 1986).

Additional preventive cultural practices to forestall pest infestation include careful selection of seeds, treatment of seeds before planting, the use of tillage to disrupt breeding cycles of insects and the utilization of ploughing and ridging to expose and destroy the development stages of insects.

Others include weeding (using hoe or by hand) and burning and/or burial of plant residues (e.g. maize stalks) which harbour pests like larvae of stem borers.

4.5.3 Traditional Water Management in Karshi and Baddeggi

Small-scale irrigation management practices form the core of *fadama* farming especially during the dry season. As with pest management, the *raison d'être* in water management is how to make the best use of water especially at times of scarcity and how to reduce risk associated with water loss. There are two main sources of water for irrigation in *fadama* areas: firstly, rivers and streams, and secondly, shallow underground water which is accessed through the digging of wells, washbowls or more recently the construction of tube-wells. Irrigation practices range from the use of watering cans and buckets as in riverside cropping, the channelling of water from rivers/streams through the use of furrows and water canals and the use of ridges and embankments through which the water flows to irrigate their fields. This process was explained by farmer in Baddeggi thus:

We usually make ridges and embankments where the water will flowthrough to irrigate the fields. Sometimes, we dig washbowls on the farms when the volume of the water in the stream goes down (during the peak period of dry season – April). Some of us use the new water pumps distributed by the government to pump the water around the farm.

The choice of a given irrigation method depends largely on the soil topography – flat land or land on a slope, soil type, distance from water source, and climate. Farmers on flat lands and those who are close to the source of water use flood and furrow irrigation methods as explained by one of the farmers in Karshi:

On a flat soil, it is easier because water is directly channelled to the farm. The land has already been ploughed and the seed beds have been made. This makes it easier forthe water to irrigate the field. On a sloppy land, it is much more difficult because you have to plan the irrigation such that water can get to the entire farm, especially the higher area. So, it is actually better to start from the higher area and let the water flow to the lower areas. The water pump is helpful in this regard.

Valley bottom/basin irrigation is particularly favoured by the farmers in Baddeggi because it is easy to construct and manage. Usually, the land is cultivated, levelled and divided into small basins to facilitate water distribution. The system is constructed such that water is diverted from valley bottom streams and channelled to the rice fields.

In Karshi, farmers that are far from the stream or those whose farms are on slopes use the traditional method of *mai jigo* (*shaduf*), a simple technique for lifting water from dugout pits at the

edge of the storm channel or ponds on the low terrace, or a well, to be distributed around the farm (fig 12). It serves as a water pump distributing water throughout the farm through canals (*doki*) that are surfaced with a water-proof material to reduce water loss through percolation. Calabashes are used on the *shaduf* to irrigate plots divided into basins (Olofin, 1993). This irrigation system, like many traditional methods, is dependent on water utilization technique for the production of rice and ideal for small-scale *fadama* farming where many of the farms are between 0.2 to 1Ha. Although small in scale and meant to cater for the family needs of the *fadama* dwellers, this traditional method of irrigation is sustainable and organically balanced.

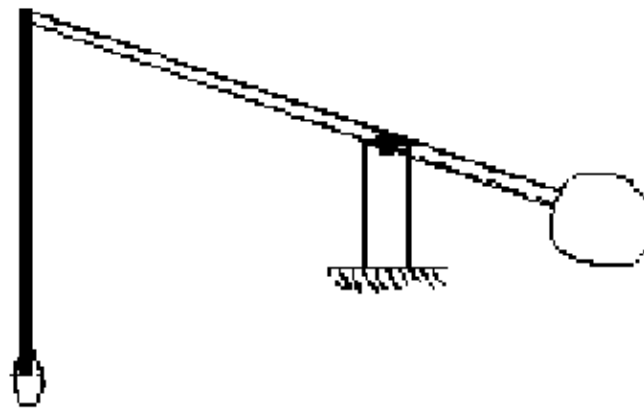


Figure 12: Shaduf for lifting water in small-scale irrigation

The rice farming practice in Baddeeggi is a carefully planned irrigation scheme that has as its main source of water supply the River Gbako, one of the tributaries of the Niger River which passes through the state. Baddeeggi, which is located 12km east of Bida town benefits from the water scheme which is supplied by gravity from headworks to irrigate most of the vast *fadama* areas (approximately 800ha). A series of simple diversion modules are used to connect irrigation canals to the river courses. The modules also check the water flow and ensure that water is shared in proportion among canals (fig 13).

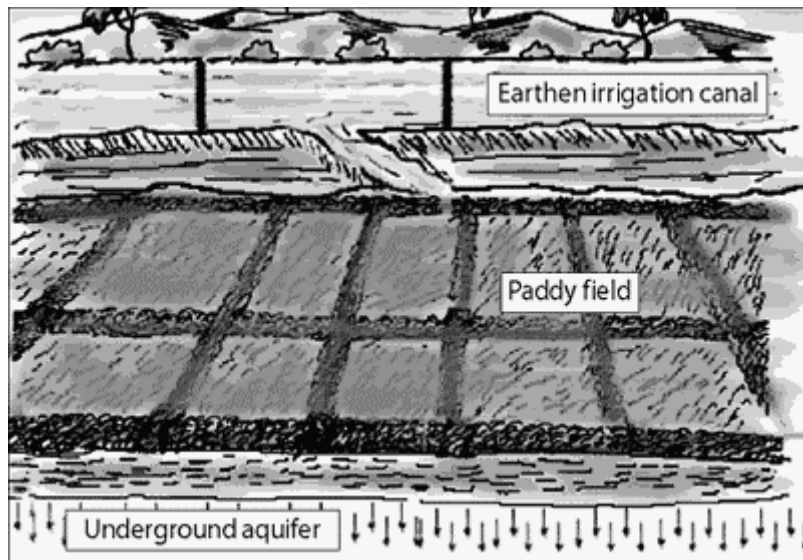


Figure 13: Paddy rice irrigation in Baddeggi

Each community has a canal that serves it, which is further divided into few user groups. The entire system is operated and maintained by the smallholder farmers who benefit from it and often involves organized community work ranging from short and light to long and intensive. Work and responsibility are designated by the community leaders without formal structure and the financial burden of maintenance, even though very little, is shared by the beneficiaries of the project (Fu et al., 2006). There exists a mutually beneficial relationship between individual farmers/households and the community as the former collectively play a role at maintaining the irrigation system so as to ensure the general stability and functioning of the community. The drainage system in Baddeggi was improved by the government (through the Agricultural Development Project) with the assistance of the World Bank in the 1980s (Olaniyan et al., 1993).

In the last few decades, however, the farmers, through a World Bank's development project running since 1983 (*Fadama* I, II and III), have been introduced to low-cost shallow tube-well technology combined with small engine-driven water pumps, a technology now referred to as "*fadama* irrigation." It formed part of the rural development package aimed at improving the productivity of the farmers through supply of technology and farming inputs, especially fertilizer.

Through irrigation, the farmers are also able to farm all year round resulting in increased productivity. Prior to the introduction of the alternative low-cost irrigation technologies, dams and large-scale irrigation were introduced in many *fadama* areas of Nigeria under the River Basin Development Authorities with wide ranging environmental consequences such as outright loss of or impoverishment of *fadama* areas (Adeniyi, 1973; Kulatunga et al., 1977; O'Reilly, 1981; Adams, 1985; Nichol, 1991). Other effects of dam construction in *fadama* areas include the dispossession of

smallholders of their land, unsatisfactory resettlement schemes, inadequate/delayed compensation and rural urban migration (Jega, 1987; Main, 1988; Olofin, 1991). In Karshi, displacement of *fadama* farmers was mainly through road construction through the community. In both Karshi and Baddeeggi, the *fadama* areas have not been significantly transformed due to dam construction.



Furrow irrigation in Karshi



The main river for irrigation in Baddeggi



A naturally recharging pond/wash bowl in Karshi



A typical irrigated rice paddy field in Baddeggi

4.6 Traditional Methods of Ensuring High Output in *Fadama* Agriculture

4.6.1 Intercropping and Maximum Land Productivity

Through traditional methods of water use and soil management discussed above, *fadama* farmers ensure stability in output and manage risks. For example, in addition to improving soil fertility and suppressing pest/disease, the practice of intercropping increases overall productivity and biodiversity in cropped fields through intensification of the farm system. When considering the choice of crops for intercropping, the farmer's decision is influenced by the desire to reduce risk associated with single crops. Other factors include: labour availability, credit, cash input, dietary needs, processing, marketability and price of produce, and social acceptability among others.

For me as small-scale farmer, when I intercrop, I will do just single weeding and this takes care of weeding for both crops. This saves me labour, maximises yield and maximises the use of land. This way I get the best from the land without damaging it.

In the same way, mixed cropping is a common practice by smallholder farmers in most parts of Northern Nigeria both in the dry and wet seasons (Alegbejo and Uvah, 1986a; Alegbejo and Uvah, 1986b; Alegbejo, 1994) for a number of reasons: meeting dietary requirements of the family (especially during the dry season), the diversification of production base, maximization of land and generation of cash to meet other social needs. Crop rotation and intercropping are closely related in both Karshi and Baddeggi as any given plot of land is likely to always have multiple crops which are rotated from one farming season to another.

Many of the farmers in Karshi intercrop maize or guinea corn with beans, cowpea and *egusi* (*Colocynthis citrullus lanatus*)⁹ with maize. The residue from the *egusi* is left on the farm to decay and enrich the soil. Previous studies in some parts of Nigeria have shown that the relative yield of maize increases when intercropped with cowpea (Agboola, 1972; Adetiloye, 1980; Ogungbaide et al., 1996). Intercropping maize with melon in contrast minimally increases yield as melon modifies soil temperature and moisture (Olasantan, 1987). Additionally melon serves other benefits such as protecting the soil against insolation, helping water infiltration into the soil, and minimizing heat and water loss through evapotranspiration during the day (Bentilan et al., 1974; Olasantan, 1987). Furthermore, intercropping maize with melon significantly reduces weeds cover on farms thus serving as a weeds control measure (Ogungbaide et al., 1996). The decision on which crop to combine with maize depends on the farmer's aspiration and needs.

⁹One of the about 300 melon species found in tropical Africa

The practice of intercropping cassava (*Manihot esculenta*) and maize (*Zea mays* L.) is similarly common among the farmers in Karshi. This choice for many of the farmers interviewed is influenced by the following factors: market value, dietary needs and food value, security in the event of crop failure, maximum land productivity and high yield. Previous research shows that intercropping cassava and maize results in significantly higher total yields (Zuofa et al., 1991); increased land productivity; improved total calorie yields/unit area/unit time (Ikeorgu et al., 1989) and better weed control (Zuofa et al., 1991).

Similarly, banana/plantain farmers intercrop it with cowpea and maize especially at the early stages of growth. Banana/plantain, a perennial crop, takes longer to mature and requires maximum spacing between suckers at planting. The precision involved in this process was explained by a farmer in Karshi:

When planting, the spacing must be right for a good yield. This is so that when they take root, they will have enough room to take in air, rain and sun and hence produce well... if the spacing is not enough, there will be too much competition between suckers.

As maximum land productivity and weeding technique, cowpea/maize is likewise planted between the banana suckers. Intercropping also has remunerative benefits for the farmers. Furthermore, in the event of the failure of one crop (either due to pest/disease attack or rainfall shortages) the farmer can fall back on the second or third crop for his/her subsistence. The practice and benefits of intercropping banana/plantain with food crops such as maize, cocoyam and vegetables has been observed in the Andes region of South America (Stover and Simmonds, 1987), the Philippines (Rao and Edmund, 1984) and West African rainforests (Wilson, 1987; Ikeorgu et al., 1989; Oko et al., 2000). Research has shown that when intercropped with cowpea, banana/plantain yield compares favourably with monoculture plantain due to cowpea's small stature and nitrogen fixing ability. However, because of maize's high nutrient requirement, competition often results which then affects yield, especially because in its second year (the productive phase) plantain makes demand on soil nutrients (Stover and Simmonds, 1987; Oko et al., 2000). Similarly, cowpea yields are affected once the plantain/banana reaches advanced stage of maturity as cowpea performs better under little or no shade (Oko et al., 2000).



Intercropping plantain and maize in Karsh



Intercropping yam and maize in Karshi



Intercropping maize and melon in Karshi



Intercropping cowpea and maize in Baddeggi

4.6.2 Integrated Farming in Karshi and Baddeeggi

Integrated farming is a common practice among many smallholders in Nigeria (Ibiwoye et al., 1996; Nnaji et al., 2003). Through integrated animal/fish-crop farming, *fadama* farmers operate a sustainable production system that also ensures increased productivity through maximization of the meagre resources at their disposal. The two systems operated by the farmers are: (1) combining crops and ruminants (mainly goat and sheep – and sometimes a few cows), and (2) combining crops and non-ruminants/poultry (chickens, grasscutters (*Thryonomys swinderianus*) and fish ponds) (fig 14). There is a mutual symbiosis between crops and animals in a way that reduces risk and increases efficiency of their farming systems. Thus, the farmers benefit from manure from the animals and are able to reduce dependency on external inputs.

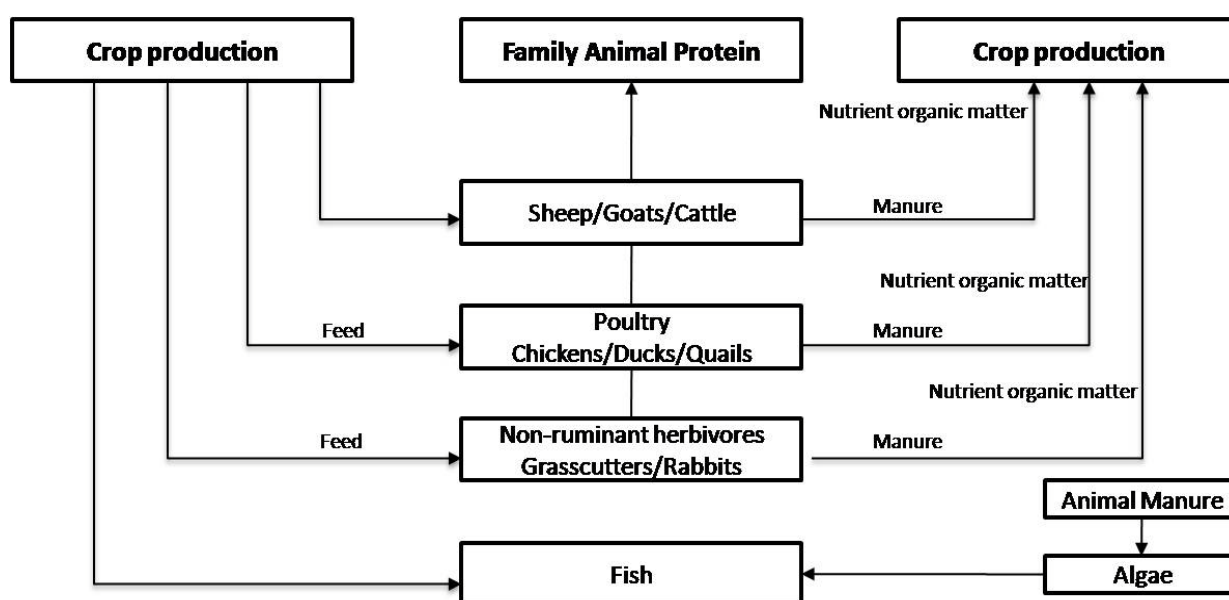


Figure 14: Mixed farming and integrated animal production using short cycle animals

In the first type of integrated farming (crops and ruminants), the farmers rely on a sustainable interaction between livestock and crops. Livestock are raised for meat, economic purposes and for manure. This system is economically profitable to the farmers on all of these fronts. The second system, integrated agriculture-aquaculture system is also common among the farmers in Karshi community. Whereas some of the farmers rely on processed pelleted feed from manufacturers to feed the fish with, a sizeable number of the farmers rely on crop and/or animal residues/manure. The key ingredients in the local fish feed are easily obtainable on the farm as explained by a farmer:

The local one is a mixture of soybeans and dry fish and also maize. The soybeans and maize are first of all fried and then ground to powdery form. Then it is mixed with crushed dry fish. Then the mixture is moulded into several little pellets.

This system is environmentally sustainable with regard to manure loading and nutrient cycling (Gabriel et al., 2007). Integrating crops and poultry also has several advantages. Birds are raised both for meat and eggs. Poultry droppings are an important source of manure both for crops in the field and also for feeding the fish or fertilizing the pond.

In general, the benefits of integrated farming include environmental sustainability (for instance, through reduced use of external inputs like fertilizer), profitability and increased crop yield at lower cost (less need for purchase of chemical fertilizer). Also, it enhances the resilience of farmers and reduces risk. Importantly also, integrated agriculture helps to reduce environmental pollution due to pesticides use.

Grasscutters (*Thryonomys swinderianus*) have been recently incorporated into the farming system in Karshi. Grasscutter is the second largest rodent in Nigeria and an important crop pest. The growing popularity of grasscutters can be explained by the following factors: first, it is cheap and requires very little initial capital to set up (NGN20, 000 - £100); secondly, grasscutters are highly productive with one male and four females able to give birth to 80 grasscutters in a year –(average litter size of 10, twice a year)(Onwuemenyi, 2008); thirdly, it provides a means of employment; fourthly, the returns from sale of grasscutters (consumed as a delicacy) is high; fifthly, it is a very rich and alternative source of animal protein (it has very low fat content) and finally, it is sustainable as the grasscutters are fed with grass and/or crop residues and their droppings can also be used as manure. The expansion of *fadama* agriculture to incorporate grasscutters shows the flexibility of willingness of farmers to experiment and adopt practices that are profitable and compatible with their cultural practices. It also illustrates the resilience of *fadama* agriculture through a rational exploitation of wildlife in order to mitigate risk.



Short-cycle animals in Karshi



Natural fish pond in Karshi



Poultry farming in Karshi



Grasscutter farming in Karshi

4.6.3 Recession Agriculture (*Noman Rani*) in Karshi and Baddeeggi

Fadama lands retain water which is easily accessible to farmers during the dry season. This makes *fadama* a highly valuable asset (Singh, 1982). The farmers utilize this water for irrigation purposes and dry season farming to cultivate mostly vegetable and sometimes cereals and some root crops like potato. Using mostly simple irrigation techniques (described above) to harness water, the farmers are able to increase their output and enhance productivity. The main vegetables grown by the farmers include onion, pepper, tomato, and okra. Other crops grown by the farmers in the dry season include rice and tubers such potato, wheat and cassava.

The popularity of dry season farming among *fadama* farmers can be explained by the following reasons: firstly, it represents a period in the year when there is slack agricultural activity and hence they are able to pay more attention to it. Secondly, there are fewer incidences of pests and diseases at this time of the year. Thirdly, most vegetables do better under the cool and dry conditions which prevail in the dry season (Okosun et al., 1996). Finally, it serves as an alternative and viable source of income not just for rural dwellers but increasingly in peri-urban and urban areas where *fadama* dry season farming is used for the production of vegetables and cereals (Ladele and Omotesho, 2000; Ojo, 2000).

4.7 Risk Management (*rage asara*) in *Fadama* Agriculture

One of the overriding concerns of *fadama* users is, as shown in the discussion on indigenous resource management techniques, risk management as farmers are constantly adapting local knowledge and farming practices to meet new needs. This is referred to as *rage asara* in Hausa and literally translates to risk reduction and is meant to ensure that output is consistent over long periods of time. As earlier mentioned, *fadama* users (like most smallholders in developing countries) face increased challenges from biophysical and socio-economic pressures which make their systems vulnerable. Vulnerability refers to a system's susceptibility to harm or the potential for loss within it (Smit et al., 1999; Luers et al., 2003). The shocks to *fadama* agriculture can be attributed to multiscalar stressors that include climate change (e.g. changing rainfall patterns and drought), policy shocks (e.g. inconsistent and insufficient policies with regards inputs and subsidies and the difficulty in securing affordable inputs), institutional weakness (e.g. poor infrastructure and services), population explosion and man-made disasters (e.g. erosion due to road construction) among others. It is widely acknowledged that these stressors combine to increase the vulnerability and reduce the resilience of smallholder agriculture (Devereux and Maxwell, 2001; OECD, 2005; Ferguson, 2006; IPCC, 2007b). For instance, climate change can negatively affect smallholders by undermining their environmental capacity to produce while economic crises can affect them by

increasing income risks and reducing their purchasing power (Adger, 1999; Dercon, 1999; Todaro, 2001; Skoufias, 2003). The challenge for *fadama* users is how to withstand these multiple shocks.

The most important risks (defined as an uncertainty that matters (Harwood et al., 1999)) facing *fadama* users relate to (1) production/yield due to the reliance of agriculture on unpredictable factors such as climate and rain (2) institutional risks, i.e. changes in policies and regulations that directly affect smallholders, e.g. policies on fertilizer subsidies and (3) price/market, i.e. fluctuations in prices. Risk management in *fadama* involves choosing among alternatives that reduce these risks and promote the welfare of the farmer. To effectively reduce risk and cope in a changing environment, *fadama* users adapt by taking in new ideas and testing, adopting or discarding them according to their needs. The main risk management strategies of many *fadama* users are centred on agricultural adaptation.

The concept of 'agricultural adaptation' is often linked with that of 'resilience' in the literature. Resilience has been defined as a systems capacity to adapt to change while maintaining its functions and control (Carpenter et al., 2001; Gunderson and Holling, 2001). Resilience and the adaptive capacity of a farming system are also closely related to the concept of sustainability (Folke et al., 2002). According to Carpenter et al., (2001), a resilient system has the following features: (1) a buffer capacity which refers to its ability to undergo change while maintaining its function (2) the ability to self-organize which determines its survival independent of external variability and (3) the ability to build adaptive and learning management techniques in a progressive, iterative and experiential way.

An important asset in achieving this stability in *fadama* systems is knowledge of: soil types, soil fertility, types and prevalence of weeds and importantly of rainfall patterns (as discussed above). The choice of farming methods and practices (for soil and water conservation), their development, modification or outright rejection by the farmers in Karshi and Baddeggi, depend on the extent to which they mitigate risk and ensure stability in the farming system both in the interim but also in the long-run. Biophysical and climatic factors (low and often erratic rainfall patterns) and available tools and resources determine what approach the farmers take to resource management. For instance, farmers often choose to broadcast seeds and save the labour and environmental damage that result from excessive land tillage. In the face of alternative choices, farmers decide on methods that are less demanding of labour, more cost effective, sustainable and above all, practicable and attainable. They also engage in soil and water conservation as described above in order to reduce risk.

The centrality of risk management to *fadama* farming is reflected in the diversification of the farming system (e.g. mixed cropping-use of different crop varieties and integrated farming). Such diversification reduces vulnerability of the farming system and enhances farmers' coping strategies. Another advantage of mixed cropping in mitigating risk is that it results in efficient use of water and reduces the risk of complete crop failure due to climatic or other biophysical events. Some other varieties of mixed farming practiced in the study areas involve the combination of short cycle animals and crops discussed above.

Other farm level adaptations include: adjustments in planting and harvesting dates and use of labour saving strategies (use of simple tools and community labour (*gajya*)). Also, crop choice by *fadama* farmers strikes a balance between risk minimization and profit maximization as will be seen in the poise of choice between high and early performance hybrid seeds and local resistant varieties. Diversification mitigates risk by easing the effects of erratic and low rainfall patterns through increased use of irrigation and simple irrigation technologies (e.g. China type pumps) so as to efficiently use available water and planting of drought resistant varieties (e.g. New Rice for Africa (NERRICA)).

Another example of diversification is seen in the ability of *fadama* users to engage not only with and in different farming systems but also different forms of occupation (artisanship, drivers, butchers, etc.). This means that *fadama* farmers ensure resilience by incorporating structural change so as to perpetuate their production models (van der Leeuw and Aschan-Leygonie, 2000). In general, diversification is done either through actual increased diversification or by careful crop management to mitigate the negative effects of climatic variations.

Fadama agriculture is dynamic and continuously changing to adapt to new crop varieties and cropping patterns. Farmers test new crop cultivars alongside existing varieties, thereby improving the genetic pool of existing crops and maximizing resistance to disease, pest and drought. However, hybrid seed varieties (favoured by official government policy) were found to be competing with traditional *fadama* varieties (such as local egg-plants, vegetables and rice, etc.) thereby threatening to reduce genetic diversity of local varieties.

Findings from both Karshi and Badeggi show that flexibility characterizes decision making regarding resource management. For instance, farmers use agrochemicals, hybrid seed varieties and other inputs alongside traditional methods to bolster their productive capacity. This flexibility has been found to be the characteristic feature of environmental management in the savannahs and arid regions of Nigeria (Kolawole, 1991).

Fadama farmers also adapt with regards the market as explained by an extension worker in Baddeggi:

The farmers have figured a way to deal with some of the problems of pricing. They sometimes store their yams until way into the year when the product is scarce. It is then that they bring it out because they are sure to get good returns. When they sell to middlemen they usually increase the prices knowing that the middlemen will in turn get good money from the cities. Also, when a middleman meets you at home, you decide the terms and you can decide not to sell at all. But when you take it to the market, then you are probably to accept less either because you desperately need the money or because you don't want to transport the yams back home at a loss to yourself.

4.8 The Importance of Indigenous Knowledge in Biodiversity Conservation and Risk Management in *Fadama* Areas

Different societies have certain knowledge systems that are unique to them and sometimes distinct but not necessarily contradictory to international knowledge systems. Indigenous Knowledge (IK) represents a society's information base derived from decades of experimentation and modification (deriving from trial and error and contact with external systems). IK is, therefore, dynamic and guides decisions regarding important aspects of community life such as resource management and agricultural production (Warren, 1991 ; Flavier et al., 1995). IK is part of the corpus of global knowledge and can be modified and adapted for use elsewhere. IK is also important in maintaining the identity of a people. By depending on IK, a given people is able maintain its livelihood by drawing on the peoples' skills and collective experiences and history (World Bank, 1997). IK is important in other areas as animal production, healthcare, local economy, poverty alleviation and community development.

One of the most critical roles of IK in *fadama* areas is in biodiversity conservation and risk management as discussed above. This is mainly through mitigation and adaptation. It has long been acknowledged that communities in the sahelo-sudan savannah areas of Africa have often relied on IK to reduce vulnerability to natural and man-made challenges as well as high population growth (Benson and Clay, 1998; Hulme et al., 2001; Nyong et al., 2007). This has led some to argue that IK is crucial in the development of effective, cost-effective, participatory and sustainable adaptive strategies in a changing environment (Hunn, 1993; Robinson and Herbert, 2001).

As previously shown, *fadama* smallholders are excellent managers of agricultural resources based on experience and inherited knowledge. It is important to note that although the traditional risk

management techniques discussed above are mostly carried out as natural resources conservation measures, research has shown that they serve the dual purpose of “reducing the emissions of GHG from anthropogenic sources, and enhancing carbon “sink” both of which are important in light of climate change (Nyong et al., 2007). Also, IK is central to efficient environmental resources management practices that include low tillage, mixed cropped, crop and job diversification, integrated farming and adjustment in planting/harvesting times. In turn, these methods help *fadama* users to cope with or adjust to the impact of changes and hence reduce vulnerability.

Integral to the evolution of IK in the area of land management is a consideration for expected gain over time. In other words, farmers in both Karshi and Baddeeggi choose methods that optimize their output while ensuring stability over time. This is even more so with population growth and disappearance of the fallow system which had hitherto encouraged the development of forests especially among banana growers in *fadama* areas. Decisions involving soil management (identifying fertile soil and improving depleted ones) are based on IK. Soil qualities such as colour (*kala*), texture, fertility (*karfi*) moisture content (*lema*), and the types of weed that grow on it, all form part of the comprehensive traditional method of soil assessment. Based on these properties, the farmers decide when to plant (beginning, mid or end of the rainy season) and the type of soil improvement methods to use. Thus, they are able to mitigate risks and increase/maintain their productivity.

In addition to these traditional adaptive measures however, members of both Karshi and Baddeeggi communities also draw from technological innovations and external inputs (discussed below) in order to function under new and challenging conditions. All these show the ability of small-scale indigenous farmers to experiment, improve and develop new systems specific to their context (Haugerud and Collinson, 1991 ; Lamola, 1992 ; McCorkle and McClure, 1992). In general, the logic of traditional methods and practices are now better understood and appreciated among agricultural experts in the West(Altieri, 1987).

IK has also been recognized to be important in the conservation of biodiversity and also achieving sustainable development (Richards, 1985; Posey and Balee, 1989; Oldfield and Alcorn, 1991). Biodiversity conservation itself is a significant risk reduction strategy. For instance, traditional knowledge in the area of seed selection helps to preserve genetic information of local varieties and indigenous species. The process of seed selection is usually complex and draws from IK as this Karshi farmer explained:

Seeds are usually carefully selected from the farm at harvesting. It is usually picked from the best performing crops – those with good, strong yield. Those are kept as seeds. It is meticulously done one after another. Once it is brought home, the seeds, especially from the serial is carefully

woven into each other (more like a belt to be worn) and left to dry either in the sun or it is hung above the fireplace in the kitchen so that it dries from the heat and it is protected by the smoke from the wood. Then it is kept in the barn.

Thus, seed selection is a careful procedure meant to protect the phenological integrity of traditional seed varieties. The qualities of the seeds which include ear characteristics, presence of insect holes, size, earliness, shape, colour, are all considered important in seed selection.

A striking element of the IK of the people of Karshi and Baddeggi with regard to agricultural production is that it is extensive resulting from experimentation and practical judgement, developed and modified over generations in line with the environmental and climatic challenges that confront them. The agricultural practices and methods of two communities are not arbitrary but the result of continuous experimentations. For instance, farmers initially experiment with new seed varieties/cultivars on a limited scale to test suitability and output before widespread adoption explained by a Karshi farmer:

Once we are given seeds by extension workers, we try them out on one section of our farm. Sometimes everything goes on well but at other times there are problems. For instance, we discovered that with these new seeds, we had problems with birds – they particularly liked that type and they sucked out the juice out of the young rice ears. So, we decided not to use that type.

Through experimentation, the farmers are able to breed better varieties of crops and animals and promote diversity through the control of genetic resources. The farmers are able to prioritize and make distinction between seed crops grown strictly for monetary purposes and those grown for consumption in the house, use for local brew and rituals.

Traditional methods of storage, even if limited, exemplify the accumulation of knowledge over time. Crops such as maize, sorghum, rice and guinea corn are usually stored in barns. The barn is first prepared as explained by a farmer in Baddeggi:

We store our grains in the barn. First, we use the bark of the alligator pepper tree (traditionally called sumo) to treat the walls of the barn. The pepper is peeled, cooked, and then it is applied to the inside walls of the barn. After that, we then store the rice. That way, it can remain in the barn in good condition for several years.

To reduce the moisture level in the barn and also keep away insects, the traditional cooking place (tripod) is constructed right next to the barn. The heat keeps the barn warm and dry while the smoke from the cooking keeps away different types of insects. This was explained by a Karshi farmer:

The main reason for making a cooking fireplace next to the barn is that it keeps off the insects that usually attack grains especially guinea corn. The insects cannot survive the heat for too long. But also it keeps the crops dry even during the rainy season. If the grains are stored outside, the rains could affect them. Grains have to be stored well, especially parts of the grains that is being kept for use as seeds for the coming farming season.

Different crops are, however, stored differently. Yams, for instance, are kept in dry but cool and airy shades to ensure that they do not start to germinate or rot.

IK is also reflected in the use of traditional methods to treat diseases as explained by the chief of Karshi:

Our people still use traditional medicine for the treatment of diseases from common illnesses like common ones like malaria to more complicated and rare ones like cancer. The herbs we use occur naturally in the wild. Take for instance typhoid fever; we have a collection of herbs which are collected, boiled and the resulting solution given to the patient to take. In a matter of days you can notice its effect, right from the colour of your urine and your body temperature. At other times, it is backache which is common among our farmers. We also have a treatment for that which also serves as a pain reliever and deals with muscle-ache. We have broad spectrum medicines that keep you fit and healthy. Some of the ingredients in these mixtures include paw-paw leaves, shea-butter tree leaves, locust bean tree and leaves from wild orange trees.

It is apparent that the acceptance, rejection or modification of technology and other development inputs among farmers in Karshi and Baddeggi is not arbitrary but carefully constructed based on their understanding of their conditions and circumstances. In other words, they never totally accept nor reject development plans in a haphazard manner but consider how these agree with their environment and experience. Hence, they negotiate meaning and are able to sift through the options available to them in order to choose what they consider to be the best option. They are also able to modify whatever 'innovation' they are introduced to such that it fits into their millennia of practice. For instance, they accept hybrid seeds but restrict its use to only the commercial while keeping the local variety for food and brew. Similarly, many of the farmers use external inputs such as fertilizer and pesticide for their expediency only but maintain the use of organic fertilizer like compost and animal manure. In fact, many of the farmers realize that chemical fertilizer affects the taste of crops like banana and also vegetables and fruits in general.

The agency called into play when negotiating meaning can be seen in the farmers' perception of themselves and their abilities. This is often juxtaposed with the 'other's' (government, development workers) perception of them which then forms the basis for power relation/exchange. Despite

their perceived sense of self-worth, ability and knowledge, they regard themselves as powerless in the face of so called 'superior' mainstream milieu. For instance, the farmers loathe that they are undervalued and unsupported despite their potentials and the fact that they provide the food needs of most of the population. They were angered by the decision of the Nigerian government to import rice worth \$1.3 billion in 2009. For them, it signified misplaced priority and policy which should be more inward-looking and targeted at self-reliance through local production rather than dependence on importation. This sentiment was expressed by a farmer in Karshi:

I can assure you that ten farmers of my type can feed this whole village if we have the support we need. But we are often left on our own. No help from the government – it is solely our effort. It is sad to hear that this country is buying food from outside. I would have thought that we should be the ones selling them food but sadly it is being brought to us? I find that problematic. We have enough land to grow food to feed ourselves and to sell to others. It is a thing of shame that we cannot do that. Very few places have our type of land and manpower. I am ashamed and sad that as a farmer, I am not taken in high regard. Well if the government wants to ignore us, let them go ahead. White people will continue to bring us food, some of which we don't even know its source, at the end, it is we as a people that are the losers not just the poor farmer like me.

Fadama agriculture provides not just a means of livelihood for farmers but is also an important tool of empowerment. It enables farmers to take control of and make decisions about their livelihoods. This is particularly true for women for whom farming is an important tool for self-expression and socio-economic empowerment no matter how limited. However, despite their role in maintaining livelihoods and indeed their contributions to global knowledge systems in such areas as medicine, IK has long been undervalued (Jackson, 1987; Liebman, 1987; Slikkerveer, 1989; Warren, 1989; Slikkerveer and Adams, 1996; Slikkerveer and Quah, 2005).

Despite recent discourse on the validity of IK, findings from both Karshi and Baddeggi show that in practice this has not yet happened as seen in the structural and institutional neglect of indigenous systems whose potentials have not been fully utilized in the development process. They are often regarded as out-dated and unproductive. Hence, development and agricultural policies always stress technology transfer at the expense of local experiences and practices. This is reflected in, for instance, the promotion of hybrid seeds as against resilient local varieties, agrochemicals in place of cultural and biological methods of pest/disease control and mechanization in place of sustainable practices such as minimum tillage and ridge planting. Development agencies need to properly study and document the benefits of IKS and incorporate them into policy planning. For

instance, many of the traditional methods discussed above are cost effective, sustainable, and practical (Richards, 1989; Warren, 1989; National Research Council, 1992; Warren, 1992).

However, in trying to access IKS, there are obvious obstacles such as bias, prestige, language and the gap between practitioners and academics that need to be overcome. This has to be done incrementally but with persistence. Also, some traditional societies are suspicious of outsiders just as they are often reluctant to disclose some of their accumulated knowledge. For instance, in Karshi, the chief refused to disclose certain ingredients (mostly plants and herbs) used in medicines and traditional mixtures for the control of pests and diseases. This monopoly of knowledge is often cultural, restricted to certain groups/class of people and secretly protected and sometimes is as a result of fear of exploitation by outsiders as explained by Karshi village chief:

I have told you some of the trees we use in making local medicines but I can't tell you about the others because they are our traditional secrets. You have to stay here and live with us to learn them...Sometime back, people (researchers) came from the big cities and from outside [overseas] and asked my dad how different ailments like stomach ache, back ache, pile are treated in this place. My dad explained to them, collected some plant types and gave them for specific diseases. They took them away to try and they confirmed exactly what my dad had told them. They sold it to their people and gave us nothing.

Like any knowledge system, nevertheless, IK is limited and amenable to improvement. Similarly, not all of what is contained in the IK canon might be relevant in fast changing times and climatic fluctuations. The challenge is to put concerted effort in the study of these systems in order to understand and test them with the view to harnessing the great potentials they present. Thus, research in the area of traditional crop and livestock management systems need to be encouraged and expanded especially in academic circles, specifically in Africa. It is by doing this, in whatever little way, that the IKS can be reclaimed, especially those important agricultural practices that have or are gradually disappearing. Finally, IK alone cannot solve the problem of low output of farmers in Karshi and Baddeggi, and indeed the whole of Africa. There is need for creative and honest engagement of IKS with mainstream modern knowledge system so as to create a system that best responds to the needs of people in the developing world.



Fire-place drying of seeds/grains in Karshi



Fish smoking for preservation in Baddeggi



Barn/fireplace for grain storage in Karshi



Sun-drying in Karshi

4.9 Mechanization and Agrochemicals Use in Karshi and Baddeggi

4.9.1 Mechanization in Karshi and Baddeggi

The percentage of farmers who use tractors for land preparation is higher in Baddeggi (27%) than in Karshi (less than 10%). For many of the farmers, lack of labour saving technologies represented a major constraint on their production. Much of the land preparation is done using traditional methods of slashing and hoeing, removal of organic debris and pre-plant burning. Generally, there are no tractors in Karshi and the cost of hiring one from elsewhere is prohibitively high. Also, many of the farms in Karshi cannot be accessed tractors because of their location (often on hills or deep in the hinterland). Land preparation, therefore, involves land clearing, manual hoe tillage, zero tillage and animal traction.

4.9.2 Fertilizer Use in Karshi and Baddeggi

The use of external inputs (fertilizer, herbicides and insecticides) in *fadama* areas is pervasive in the farming communities of Karshi and Baddeggi and is considered by many to be a pre-requisite for successful/plentiful harvest and hence the best and most expedient way to improve soil fertility, control weed and pests. As shown below (table 21), the bulk (78.7%) of the farmers interviewed in Karshi use chemical fertilizer (either by itself or alongside organic fertilizer). In Baddeggi, 71.4% of the farmers use fertilizer while 28.6% use organic fertilizer alongside chemical fertilizer.

Table 21: Use of external inputs among Karshi and Baddeggi farmers

	Karshi			Baddeggi	
		Frequency	Percentage	Frequency	per cent
Fertilizer	Yes	37	78.7	15	71.4
	Alongside organic	10	21.3	6	28.6
	Total	47	100.0	21	100.0
Herbicide	Yes	43	91.5	18	85.7
	No	4	8.5	3	14.3
	Total	47	100.0	21	100.0
Insecticide	Yes	23	48.9	8	38.1
	No	24	51.1	13	61.9
	Total	47	100.0	21	100.0
Hybrid seeds	Yes	20	32.6	18	85.7
	No	27	67.4	3	14.3
	Total	47	100.0	21	100.0

The common inorganic types of fertilizer used are, Urea and NPK (nitrogen, phosphorus and potassium). Urea is a quick release synthetic fertilizer containing a minimum of 46% Nitrogen calculated in dry state. NPK contains three basic nutrients required for plant growth: nitrogen is mainly for leaf growth, plant proteins and also chlorophyll whereas phosphorus contributes to the

development of root, flower and fruit. Potassium on the other hand helps in stem/root growth as well as protein synthesis.

87% of the farmers use between 100kg to 300kg and none of the respondents used above 500kg per hectare. The average rate of fertilizer use (for most cereals and tuber crops) is mostly less than 200kg/ha, which falls far below the level recommended by the Agricultural Extension Research and Liaison Services (AERLS) of Nigeria (table 22). For instance, the recommended level for lowland rice is about 300 kg/ha (first application of 200 kg/ha of NPK, 15:15:15 and 100 kg/ha of urea for second application).

Thus, even though use of fertilizer is widespread across both Karshi and Baddeggi, the quantity is usually low due to non-availability and high cost. Thus, many of the farmers apply as much as they can get of the chemical fertilizer or fall back on organic fertilizer.

Variety	Rate	Time
Maize Open Pollinated Hybrid	<i>Forest Fallow Over 10years</i> 200 kg (4 bags) of NPK 25-10-10/ha- (Equivalent to 50 kg N, 20 kg P ₂ O ₅ and 20 kg K ₂ O/ha).	At planting
	<i>Forest falls less than 10 years/ soils under savannah vegetation and soils under continuous cropping</i> 300 kg (6 bags) of NPK 25:10:10 and 100 kg (2 bags) of Single Super-phosphate per/ha (Equivalent to 75 kg, 50 kg P ₂ O ₅ 30 kg K ₂ O, and 14 kg S per/ha). Or 400 kg (8 bags) of 20:10:10-2S-1Zn per/ha	At planting
	Savannah zone 400 kg (8 bags) of 25:10:10, 100 kg (2 bags) of Single Super-phosphate and 3 to 5 kg of Zinc Sulphate per/ha (to give 100kg N, 58 kg P ₂ O ₅ ; 40 kg K ₂ O, 14 kg S and 1 to 2 kg Zn per/ha) Or 500 kg (10 bags) of 20-10-10-2S-1Zn per/ha	At planting
	For every high yield, 600 kg (12 bags) of 25:10:10/ha (to give 150 kg N, 60 kg P ₂ O ₅ and 60 kg K ₂ O/ha OR In the savannah additional 200 kg (2 bags) of Single Super-phosphate and 5kg of Zinc Sulphate to give a total of 150 kg N, 78 kg P ₂ O ₅ , 60 kg K ₂ O, 14 kg S and 2 kg Zn.	2 Split – 200kg/ha at planting and 5-6 weeks after planting
Rice Upland	100kg of 15-15-15/ha (2 bags/ha) 50 kg (1 bag) of Urea/ha	Basal application (2-3 weeks after emergence) (5 weeks after sowing)
Lowland Tall Lodging Indica Varieties	200 kg (4 bags) of NPK 15:15:15 100 kg/ha (12 bags) of urea 200 kg/ha (4 bags) of NPK 15:15:15 100kg (2 bags) of urea	2 weeks after transplanting At ear initiation Before transplanting 30 days after transplanting

Improved non-lodging Indica Varieties	100 kg/ha (2 bags) of Urea/ha	At ear initiation
Yam	<p>Forest zone under continuous cultivation 400 kg (8 bags) of NPK 15-15-15/ha (60 kg N, 60 kg P₂O₅ and 60 kg K₂O/ha).</p> <p>In the savannah zone 300 kg (6 bags) of NPK 15-15-15 and 100 kg (2 bags) of urea/ha (90 kg N, 45 kg P₂O₅ and 45 kg K₂O/ha)</p>	3-4 months after planting
Cowpea	<p>Savannah Zone 50–100 kg/ha (1–2 bags) of single superphosphate OR 100 kg/ha (2 bags) of NPK 15:15:15.</p> <p>Forest Zone 50 kg/ha (1 bag) of single superphosphate OR 150kg/ha of NPK 15:15:15</p>	Before planting
Sorghum	213 kg of 15:15:15 (about 4 ½ bags) Follow up with: application of 123 kg (2 1/2 bags) of CAN	Split equal doses – 2-6 weeks after planting

Table 22: Recommended fertilizer rates for crops cultivated in *fadama* areas
Source: (ICS-Nigeria, 2004)

4.10 Overview of Pesticides¹⁰ Use in Developing Countries

Pesticides have undeniable benefits and their use in agriculture has significantly increased agricultural productivity by reducing the amount of loss to pests and diseases. The amount of loss is higher in developing countries where it is estimated to be about one-third of the actual tonnages harvested (table 23). Also, up to 40 per cent of crops are lost in storage (Ghatak and Turner, 1978). Pesticides also boost the economic potential of farmers and the attendant social benefits that come with that (Cooper and Dobson, 2007).

Thus, pesticides play a significant role in increasing production and reducing hunger especially in developing countries which are faced with problem of rising populations. Positive uses of pesticides in developing countries include locust control in African Sahel regions and rodent control in India where crop loss due to rodents was estimated at 12.5 million tons in 1973 (Gunn and Stevens, 1976). There is little doubt, therefore, that “pesticides have reduced insect infestation and controlled crop and livestock diseases, and reduced the risk of major typhus and malaria epidemics” (Ghatak and Turner, 1978).

¹⁰A pesticide is any inorganic substance or mixture of substances (sulphates, arsenate's, chlorides of lead, copper and so forth) intended for preventing, destroying, repelling, or mitigating any pest. Pests can be insects, mice and other animals, unwanted plants (weeds), fungi, or microorganisms like bacteria and viruses. Thus, it refers not only to *insecticides* but also to herbicides, fungicides, and various other substances used to control pests. In some places (the US), a pesticide is also any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant (EPA, 2009). Global marketing of pesticides is controlled by a small group of transnational corporations based in Western Europe and the U.S. The corporations include Ciba-Geigy, ICI, Rhone Poulenc, Bayer, Du Pont, DowElanco, Monsanto and Hoechst (Frey, 1995)

Region	Pests (Insects) %	Diseases %	Weeds %	Total %
N. & Central America	9.4	11.3	8.0	28.7
S America	10.0	15.2	7.8	33.0
Europe	5.1	13.1	6.8	25.0
Africa	13.0	12.9	15.7	41.6
Asia	20.7	11.3	11.3	43.3
Oceania	7.0	12.6	8.3	27.9
USSR & China	10.5	9.6	10.1	29.7

Table 23: Crop losses to pests, diseases and weeds, by geographical areas
Source: (Speich, 1972)

The largest users of pesticides are developed countries (Western Europe, North America and Japan) followed by Asian countries and Australia. However, developing countries (in Latin America, Eastern Europe and Africa) have substantially increased their pesticides use in the last few decades making pesticides an important market in those countries (Weir and Shapiro, 1981; Postel, 1987). Between 1972 and 1985, pesticides imports grew by 261 per cent in Asia, 95 per cent in Africa and 48 per cent in Latin America) and by 1991, developing countries are said to account for over 30 per cent of total world pesticide consumption compared to 22 per cent in 1985 (Frey, 1995). Pesticide use in Africa accounts for about 2-5 per cent of the global pesticide market of US\$31 billion (Williamson et al., 2008). Herbicides are the most commonly used pesticides and represent around 50 per cent of all crop protection used throughout the world (insecticides and fungicides account for around 17 per cent each) (Cooper and Dobson, 2007). The consumption of pesticides has increased in many developing countries due to change and transition in the structure of production. Migration to cities means fewer people are involved in agricultural production for themselves and for the new, industrialized workforce. Also, some of these countries are now involved in agricultural export of non-traditional agricultural produce to other regions of the world (Ecobichon, 2001; Fold and Gough, 2008).

However, pesticides use has several unintended environmental and health consequences¹¹. Pesticides stimulate changes in the agro-ecosystem which may be desirable in the short-term but which could result in serious ecological damage if not properly managed. There are ecological limitations to pesticides “set by an economy’s factor endowments (in terms of climate, water resources, soil types, etc.). To ignore these constraints is to risk major disruptions in the biosphere and its human carrying capacity which may threaten a population’s very survival,

¹¹ These effects are discussed in greater depth in Chapter 7

particularly an LDC's (less developed country) population of which a significant proportion lives at near subsistence level" (Ghatak and Turner, 1978, p. 136).

Many developed countries have banned or restricted the use of certain pesticides because of their environmental and health hazards. However, many of the pesticides used in developing countries are extremely hazardous categories I & II chemicals which have been banned in developed countries (Pingali and Roger, 1995). The FAO and the WHO estimate that about 30 per cent of pesticides sold annually in developing countries (totalling \$900 million a year) fail to meet international standards and are often mislabelled or entirely unmarked (Africa Recovery, 2001). They include pesticides such as dieldrin, DDT, chlordane, and a number of other highly restricted pesticides (commonly referred to as the "Dirty Dozen") (Frey, 1995, p. 153) (table 24).

-
1. **DDT**
 2. **2,4,5-T**
 3. **Aldrin (including dieldrin and endrin)**
 4. **Camphechlor**
 5. **Chlordimeform**
 6. **Chlordane (heptachlor)**
 7. **DBCP**
 8. **Ethylene dibromide**
 9. **Lindane**
 10. **Parathion**
 11. **Paraquat**
 12. **Pentachlorophenol**
-

Table 24: The Pesticide Action Network's "Dirty Dozen" List
Source: (Mazingira, 1985)

A study by the FAO in 2001 found that the stocks of deadly, obsolete pesticides in developing countries are five times larger than previously estimated (100,000 tonnes in Africa and the Middle East, 200,000 tonnes in Asia and 200,000 tonnes in Eastern Europe and the former Soviet Union). Those at more risk due to pesticides exposure in developing countries are smallholders "with a smaller average holding, who invariably use small, portable application equipment and are thus more exposed to pesticides than those using mechanised vehicle sprayers" (Matthews, 2006). In 1990, the World Health Organization (WHO, 1990) estimated that 3 million people worldwide suffer acute pesticide poisonings (from agricultural use) each year, the bulk of them are people in developing countries (some examples cited in table 25). This results in about 20,000 deaths annually.

The problem in developing countries is compounded by the lack of well-developed pesticide policies and regulations. This makes and misuse/abuse prevalent (Tjornhom et al., 1997). For instance in Nigeria, it was only in 1993 that a regulatory body for drugs and food was established – The National Agency for Food and Drug Administration and Control (NAFDAC). However, it did not pay much attention to pesticides until recently (2003) when it put in place various regulations, including the Pesticides Registration Regulations and the Chemical and Chemical Products (control, monitoring) Regulations. The latter is still in draft form, awaiting comments (Keri, 2009).

Country and year	Nature of Disaster
Oyo State, Nigeria	Many reported cases of human poisoning by gammallin 20 (Lindane) at University College Hospital, Ibadan
Vietnam, 1960	High birth defect rates recorded in areas where United States Armed Forces applied 2,4,5-T herbicide for forest defoliation during the Vietnam War
Turkey, 1982	3000 people poisoned, 330 deaths after ingesting seed grains treated with hexachlorobenzene
Tijuana, Mexico, 1968	Severe poisoning and deaths recorded for people after meal of bakery products contaminated with parathion
Iraq, 1972	Poisoning of people eating grains treated with organo-mercurial fungicide. Many deaths recorded
Pakistan, 1976	Malathion poisoning of 7500 public health field workers. 5 deaths recorded
Ondo State, Nigeria	20 public health field workers poisoned by malathion
Bhopal, India December 4, 1984	2500 people were killed in the industrial city of Bhopal due to accidental release of poisonous methyl isocyanate gas from Union Carbide's pesticide plant
La Union, Peru January 29, 1987	14 children and 1 man died while 260 people fell ill after eating bread baked from flour contaminated with Aldrin
Imo State, Nigeria	A family of 5 people died after eating meals contaminated with pesticides

Table 25: Examples of human poisoning episodes due to pesticides in developing countries
Source: (Osibanjo, 1989)

An early study on pesticides use in developing countries showed that 25 per cent of pesticides exported by the U.S. to developing countries were banned, restricted or unregistered in the U.S (Weir and Shapiro, 1981). Subsequent studies have revealed that this pattern has not changed significantly through the 1990s and may actually be on the rise. Additionally, the studies show that many of the pesticides produced and formulated under the control of trans-national corporations (TNCs) in developing countries are banned or highly regulated in developing countries due to the health and environmental risks they pose. Even when these countries have taken over the manufacturing of pesticides, it is mostly centred on the older more persistent pesticides (Castleman, 1979; Goodman, 1987; Bogard, 1989; Wright, 1990).

Thus, it has been argued that through various control mechanisms, developing countries have become dependent on TNCs in developed countries for capital, technology and manufactured goods (Frey, 1995). The increased use of pesticides in developing countries is seen to be due to external and internal pressures that promote the agricultural development model of developed countries. Agricultural policies in developing countries are seen to be based on the promotion of agrochemicals, machinery and hybrid seeds, which are seen as the pre-requisites for reducing hunger (Lappe and Collins, 1977; Goodman and Redclift, 1991; Shiva, 1991; Murray and Hoppin, 1992; Faber, 1993).

Generally, studies on the effects of pesticides in developing countries are scant and limited to the valuation of the health effects of pesticides and not on other environmental categories (Cuyno et al., 2001). Even at that, the extent of pesticide residue contamination on “local, fresh produce purchased daily or of potential, long-term, adverse health effects on consumers” is not properly understood and few developing countries have a clearly expressed ‘philosophy’ concerning pesticides (Ecobichon, 2001). Many of the studies on pesticide use in Africa centre more on poor practice (Sibanda et al., 2000; Ashburner and Friedrich, 2001; Matthews et al., 2003; Tijani, 2006) and the uneconomical use (Adipala et al., 2000; Sibanda et al., 2000; Nathaniels et al., 2003).

4.11 Pesticides Use in Karshi and Baddeeggi

4.11.1 Herbicides Use in Karshi and Baddeeggi

The prevalent types of grasses in *fadama* areas include: Spear grass (*Imperata cylindrical*), tiger nut or *aya* in Hausa language (*Cyperus esculentus* L.), elephant grass (*Pennisetum purpureum*), Bahamas grass (*Cynodon dactylon*), striga (*Striga hermonthica*), and tridex (*Tridex procumbens*). The effects on yield of these weeds range from minor to complete yield loss in the case of *striga*, which constitutes the single major threat to maize and sorghum production in Karshi and Baddeeggi.

The use of herbicide is common in the Karshi farming community as 91.5% of the farmers interviewed agree to have used it at least once during the course of the farming season. In Baddeeggi, too, herbicide use is prevalent with 85.7% using one or several of the available types of herbicides. Only 14.3% do not use herbicide.

The two broad categories of herbicides (classified by mode of action) used by the farmers are (1) contact herbicides and (2) systemic herbicides. Contact herbicides kill weeds upon contact and are effective mainly against annual weeds while systemic herbicides are translocated and absorbed within the plant system and tissues remote from the point of application, usually roots or foliar

plant parts. Most of the herbicides used by the farmers are made and supplied by different agrochemical companies based in Nigeria (Saro Agro Chemical, West African Agro, Sygenta, C.Zard and Patem Global) (see table 26).

The most common and cheaper contact herbicides popular among the farmers is Gramoxone® (a paraquat herbicide, banned in Europe and North America for suspected carcinogenicity). Usually available under several trade names (Weedoff, ParaForce), the most active ingredient in this herbicide is Paraquat Dichloride (usually 276 gms/Lt). Another popular herbicide is Pendimethalin, a dinitroaniline herbicide, which is used by the farmers as both pre-emergence and early post-emergence herbicide on rice, sorghum, sugarcane, cowpea and a range of other crops. Super amine (Weedone super d pro amine) is commonly used as a pre-emergence rice herbicide. The two active ingredients in pro amine herbicides are Dicamba and 2,4-D diethanolamine salt.

The most common post-emergent, systemic and non-selective herbicide used by the farmers in Karshi and Baddeggi is Glyphosate (N-(phosphonomethyl) glycine), marketed in Nigeria by West African Agro™. “Commercial glyphosate-based formulations most commonly range from concentrates containing 41% or more glyphosate to 1% glyphosate formulations marketed for domestic use” (Bradberry et al., 2004). It is usually used alongside atrazine (6-chloro-N-ethyl-N'-isopropyl-1,3,5-triazine-2,4-diamine), which is also a selective systemic herbicide. Propanyl (N-(3,4-dichlorophenyl) propionamide) is the commonest post-emergence rice herbicide used by the farmers in Karshi and Baddeggi. 2-4-D Amine is used both as a pre- and post-emergence herbicide for the control of broadleaf weeds.

Common Name	Trade names as sold in Nigeria	Uses	Toxicity
Paraquat	Gramoxone, Bret-P, Paraforce, Weedoff, Weedcrusher, Dragon, Dizmaxone, Lasher, Miazone, Weedex, Ravage, etc.	General weed control (by contact) in all crops	PAN Bad Actor Chemical, acutely toxic, potential groundwater pollutant, endocrine inhibitor
Atrazine	Atrazine, Delzine, Atrataf, Atraforce, Xtrazine	For the control of grass weeds in cereals	PAN Bad Actor Chemical, slight acute toxicity, carcinogenic, underground water pollutant, endocrine inhibitor
Propanil	Propanil, Propacare, Propan, Rhonil, Orizo, Propaforce, etc	For post- emergence weed control in rice	Slight acute toxicity, carcinogenic, underground water pollutant, suspected endocrine inhibitor
Pendimethalin	Stomp, Pendilin	For pre-emergence weed control in rice, maize and some legume crops	Slight acute toxicity, possible carcinogen, suspected endocrine inhibitor
Glyphosate	Roundup, Glycel, Wipeout, Clearweed, Bushfire, Forceup, Sarosate, Rhonasate, Delsate, Glyphosate, Touchdown forte, etc	Systemic herbicide for general weed control before land preparation	Slightly acutely toxic, toxic to certain aquatic species
2,4-D Amine	Aminoforce, Delmin-forte, 2,4-D-Amine, Select, etc.	For pre- and post-emergence control of broadleaf weeds	Slightly acutely toxic, toxic to certain aquatic species, carcinogenic

Table 26: Common pesticides used by farmers in Karshi/Baddeeggi and their toxicity
Source:(adapted from Dugje et al., 2008)

As with fertilizer, the use of herbicides is very prevalent among most of the farmers interviewed in both Karshi and Baddeeggi. This can be explained by the pervasiveness of stubborn weeds such as *Striga* in these areas. However, the consumption level is equally very low when compared to that on commercial farms. The majority of the farmers who use herbicide apply chemicals at a maximum level of once or twice a year (as against the recommended 3-5 times). Usually, the level of herbicide consumption also falls way below the recommended levels. For instance, majority of the farmers are not able to meet the recommended level for most of the crops they grow. The recommended dosage for rice herbicides (TamariceTM, RonstarTM, RisaneTM) is 3 kg/ha (8 litres). For maize also, the farmers mostly fail to meet up the recommended 3 kg ai/ha of Atrazine and 2ltr/ha for Gramoxone.

4.11.2 Insecticides Use in Karshi and Baddeeggi

Different pests attack different crops in the *fadama* area under study (table 27). The prevalent field pests of maize include insect pests of the seedling and vegetative parts such as grasshopper species, flea and leaf beetles, and seed and harvesting ants. Others include stem borers (among which are *Busseola fusca* (Fuller), *Sesamia calamistis* (Noctuidae), *Acigona ignefuscalis* (Hamps) and *Eldana saccharina* (Pyrlidae), earthworms and army worms.

Damage to rice in both Karshi and Baddegi as reported by the farmers is by vertebrate pests, predominantly birds and rodents. Research in parts of Sokoto, Katsina and Kano states (all in Northern Nigeria) also identified the challenge posed by birds and rodents to rice and wheat growers (Adeoti, 1996). These pests attack mostly the milking stage of the rice and ripe rice ears just before harvest. It was, however, difficult for the farmers to quantify the damage done by birds to their crops even though they believe it is substantial.

Table 27: Incidence of pest in Karshi and Baddegi

Pest	Crop Infected	Severity Rating	Reported Control Measures Adopted
Stem borer	Millet, Sorghum, Rice, Maize	High	Chemical Cultural
Grasshopper	Rice, millet, maize, Groundnut, Yam, Vegetables, Coffee	Low	Chemical
Weaver bird	Millet, Rice, Sorghum	High	
Termite	Maize, cassava, Yam, Sugarcane, Plantain	Medium	Chemical
Rodent/Grasscutter	Maize, Cassava, Cocoa, Rice	High	Cultural Chemical Poisoning
Striga	Maize, Rice, Millet, Sorghum	High	Cultural
Beetle	Millet, Sorghum, Vegetables, Cowpea	Low	Chemical

Diseases affecting maize generally include maize streak caused by the leaf hopper (*Cicadulina mbila*), leaf blight induced by *Dreschlera turvica* and *striga*, which represents the most widespread and destructive of all the maize diseases affecting farms in Karshi and Baddegi (table 28). *S. Hermonthica* is the most important maize *Striga* in most of the savannahs of Nigeria (Dike and Adeoti, 1996).

Common diseases of sorghum (*Sorghum bicolor* L.) in Karshi and Baddegi include leaf blight (*Helminthosporium turvicum*), downy mildew (*Sclerospora sorghi*) and smuts. The main types of smuts include: covered smut (*Sphacelotheca sorghi*), loose smut (*S. cruenta*) and head smut (*S. reliana*). Another major challenge to sorghum is the weed sorghum *Striga*.

Table 28: Incidence of disease in Karshi and Baddeggi

Pest	Crop Infected	Severity Rating	Reported Control Measures Adopted
Maize streak	Millet, Sorghum, Rice, Maize	Medium	Chemical Cultural
Leaf blight	Crop seedlings, Sorghum, Cowpea, Maize	Medium	-Improved/resistant varieties - Cultural - Chemical
Downy mildew	Sorghum	Medium	Chemical cultural
Smuts	Sorghum	Medium	Chemical

A sizeable percentage of the farmers in Karshi (48.9%) report the use of insecticide either on the field or in storage whereas 51.1% report to not have used any type of insecticide. Similarly, in Baddeggi, the percentage of farmers who do not use insecticide is higher (61.9%) than those who do (38.1%).

The most widespread insecticides used by the farmers include fungicide, fumigant, aphicide, acaricide and rodenticide. *Aluminium phosphide* (under the trade name Justoxin) is a solid chemical of the inorganic phosphide family which is employed by some farmers for rodent and mole control. *Monocrotophos*, a contact and systemic insecticide and acaricide is also used by the farmers for control of pests on crops like rice and maize. For storage, the common insect pest control chemical used is *Piriphos Methyl* 250g/Lt (Actellic™ – made by Syngenta and marketed in Nigeria by C.Zard™). Generally, insecticide use is not as prevalent as herbicide or fertilizer use in both Karshi and Baddeggi.



Hybrid seeds on sale in Karshi



A cross-section of common pesticides in Karshi/Baddeggi



Re-packaged urea fertilizer in Karshi



Indiscriminate pesticides handling in Karshi

4.12 Explaining Fertilizer and Pesticides Use in *Fadama* Areas

The popularity of inorganic fertilizer in Nigeria and among smallholder farmers can be traced to the 1980s during which government's support and subsidy on fertilizer led to high adoption rates among the farmers. Fertilizer then was cheap and affordable and many farmers could access it. However, the situation has changed – the price of fertilizer has skyrocketed (at the time of this research, a 20Kg bag of fertilizer sold for between NGN3,000-4,000, in contrast to the official rate of NGN1,500). In general, Nigeria's policy on fertilizer has been inconsistent and characterized by ineptitude in distribution and massive corruption of the agricultural ministry and the agencies charged with distribution (Manyong et al., 1997). For instance, in the study areas, the process of inputs distribution is deeply flawed as explained by an extension worker in Karshi:

Most of the time, they distribute the fertilizer at a time when the farmers have no real need for it, that is when it is already way into the farming season and not when the farmers need it. When the fertilizer is finally said to be available, the farmer has already bought from the black market at high prices and is not ready any more troubles.

Yet, the government continues to spend huge sums in the procurement of fertilizer which, as findings in Karshi and Baddeeggi show, never get to the intended users. For instance, the Niger state government (where Baddeeggi is located at), recently ordered 28,000 metric tonnes of assorted fertilizer at the cost of NGN2.8 billion to boost agricultural production in the state (Sanni, 2008).

Agrochemicals use is promoted by the government despite the reluctance of some farmers to adopt as a member of the agriculture ministry in Minna explained:

We try to enlighten the farmers on why they should use fertilizer and pesticides but they are sometimes very reluctant to adopt it. The main reason we promote it is that application of chemical fertilizers is easier and the results are more noticeable and direct – immediate results – compared to organic fertilizer

However, for many farmers, the use of agrochemicals is mainly for as means for reducing risks associated with poor soil quality or low fertility as this farmer explained:

The use of fertilizer depends on the area. In some places, fertilizer is required whereas in others there is no need... It depends on the fertility of the soil. Some soils are not strong (fertile). From the colour and texture of the soil, it is possible to tell... If the soil is dark and has lots of humus, then it is good. However, in some places the soil has weakened over time and therefore we must use fertilizer.

The use of pesticides is equally widespread in Karshi and Baddeggi. The most common pesticides used are herbicides which are used by farmers to reduce the drudgery associated with land preparation and weeding but also for their expediency. For many farmers, herbicides help to deal with the problem of persistent weeds. The use of pesticides in this community is better understood within the Nigerian context. Through several agricultural policies, the government helped farmers purchase pesticides and other agricultural inputs and sometimes provided them for free (Ajayi, 2000). Past and present policies foster pesticides use through subsidies, easy credit, tax incentives, agricultural extension programmes and technical assistance. This led to widespread pesticide adoption by farmers as traditional control methods were discouraged. Even with the removal of incentives and subsidies, farmers have become hooked on pesticides. Farmers in the study areas access inputs either through official means (Agricultural Development Programme (ADP) offices) or unofficial suppliers (private vendors/marketers) which are scattered throughout Nigeria's rural areas. In some cases (e.g. Karshi), these suppliers are extension workers attached to the ministry of agriculture. Much of the inputs supplied by the government are hijacked by corrupt government officials and sold at higher prices on the black market. Thus, the pattern of agrochemicals use in developing countries is directly related to changes in state and private sector provision of agricultural inputs (Ajayi, 2000; Cromwell et al., 2001; Kelly et al., 2003; Williamson, 2003).

The pervasiveness of pesticides use in the study areas questions common assumptions that their use is restricted to cash crops and that smallholders are low input, with zero use of pesticides (Abate et al., 2000; Way and van Emden, 2000; Ebenebe et al., 2001). The lower volume of pesticides used in Africa does not reduce the risks "arising from the toxicity of the compounds used and widespread serious shortcomings in handling practices" present real danger (Williamson et al., 2008).

4.13 Explaining the Re-emergence of Organic Fertilizer

Due to the high cost and apparent inaccessibility of inorganic (nitrogen) fertilizer many farmers have fallen back on organic fertilizer. Despite its lack of popularity in academic and policy circles (who consider it as tedious and backward), some researchers have encouraged and called for a return to traditional methods. Such alternatives build on traditional links between arable farming and livestock raising as is common among most smallholder farmers in Nigeria and many other parts of Africa.

One of the reasons for the fall back on organic fertilizer is, as explained by an extension worker in Baddeggi, due to an increasing awareness of the negative effects of fertilizer and pesticides use.

However, he explained that one of the major reasons for continued use of fertilizer by these indigenous farmers is because they find its application easy and are impressed by the rapid and observable effect of fertilizers:

... a lot of them [the farmers] have started to see the negative effects of the use of chemical fertilizers. So they [the farmers] are being enlightened but they are reluctant to stop the use of fertilizers simply because it seems to achieve immediate results and its application is easy.

At some other times however, some of the farmers explain their use of organic fertilizers to high price and limited availability of fertilizers as explained by this farmer:

Sometimes I don't have access to chemicals, so I weed manually and use cow dung. At other times, the chemical is insufficient, and at other times I use the time spent chasing for chemicals to just use animal droppings.

Research by Shehu et al. (1997) on the effects of green manure on maize yield, quality and soil composition showed that it is “similar to that from applying chemical fertilizer (125kg N, 30kg P, and 30kg K/ha) in the magnitude of the increase in maize leaf yield and CP concentration”. Green manure showed higher tendencies to increase maize grain yield and improved soil organic C concentration. Also, maize seems able to adapt and respond to green manure as well as to inorganic fertilizer.

Further research on the nutrient content of farmyard (cattle) manure shows it contains as much nutrient (nitrogen, phosphorus and potassium) as in inorganic fertilizer. In fact, better effects of phosphorus are observed in organic fertilizer because not so much of phosphorus is soluble at one time as for example with superphosphate, so less fixation takes place. Also, farmyard manure contains several micronutrients (Nwabueze, 1996).

Government's reluctance in encouraging the use of organic fertilizer through research and finance reflects a general institutional perception that such a venture is futile and inefficient. There is a bias for 'modern' agriculture that emphasizes more use of external inputs for increased productivity. This bias was expressed by a World Bank official in Nigeria:

In more developed countries, they have attained self-sufficiency. In fact, they're paying farmers to produce less or indeed giving all sorts of incentives, or subsidising the products or paying them to produce less at some point. This is all part of the subsidy terms in Europe and other developed parts of the world. But here we are struggling with food-sufficiency. There is manifest hunger, food inadequacy, food insecurity. So if you want to talk about the effect of fertiliser on the soil, they will tell you go and tell them in London, leave us here because we want to have enough first.

Yet, not only has the high nutrient level of organic fertilizer been demonstrated, arguments on the quality, quantity and availability of organic fertilizer have been sufficiently repudiated (Lal and Mathur, 1989; Chai et al., 1988; Swarup, 1987; Nwajiuba and Akinsanmi, 2002). The use of organic fertilizer seems ideal and suited for the purposes of the multitude of smallholder farmers who use it. Furthermore, the planting of multipurpose trees e.g. leucaena which can release up to 247kg/N/ha/yr into the soil while gliricidia can yield up to 169kg/N/ha/yr and similar indigenous tree species can be encouraged (Nwabueze, 1996).

4.14 Hybrid Seeds Use in Karshi and Baddeggi

An appreciable percentage (32.6%) of the farmers in Karshi use hybrid seeds at some point in the course of the farming season (mostly rice, sorghum and maize varieties). However, the bulk of the farmers (67.4%), even those that use hybrid seeds, continue to rely on local seeds (*dan kasa*). The rate of adoption of hybrid seeds is higher among farmers in Baddeggi than in Karshi, with 85.7% of the respondents using seeds from the research institute while 14.3% do not. These seeds were introduced to farmers by the agriculture research institutions through agriculture extension workers. The reasons for hybrid seeds adoption among many farmers is usually complex revolving around risk management and profit making as this farmer explains:

Usually we combine the two – our local variety and the foreign one – we have realized that our local variety takes longer to mature and so we plant it early (around March-April) and then plant the improved one later (between June/July). That way we get the benefit of both varieties. If one fails, then we can fall back on the other one.

As with chemicals, many of the farmers do not completely understand the threats posed by wholesale use of hybrid seeds: narrowing of the genetic pool, reliance on inorganic fertilizer and insecticides, the risk of diseases and dependence on seed companies. The attraction of hybrid seeds to most of the farmers relates to their early maturation and high yield. However, many of the farmers do not rush into production of hybrid crops. They experiment with the hybrid seeds on a specific portion of farm to determine its suitability for their purposes. In many cases, the farmers cultivate hybrid crops for sale in the city and keep the local crops for consumption and the making of local brew. They consider crops from local seeds to taste better, but more importantly, local seed varieties conform to their farming systems and environmental conditions. Despite its appeal to some farmers, they have observed that hybrid seeds do not result in high yield if fertilizer is not used. One farmer puts it this way:

Many of us really liked the foreign seeds because it performs better than dan kasa (local variety). The problem is that we discovered that unless you use chemicals and if the rain is not good, then it does not perform well and we end up losing everything. This is why we now combine the two because dan kasa is very strong and no matter what happens I am sure to get a few things [farm produce] at the end of the season.

Hybrid seeds are popular among large commercial farmers who grow crops in generally stable and controlled conditions. Significantly, the use of hybrid seeds poses a long-term threat to food security of smallholder farmers as it results in the loss of traditional seed management systems and shifts seeds management from farmers to the market, thereby placing local farmers at the mercy of profit oriented private seed traders/companies. Excessive use of hybrid seeds can also result in the disappearance of traditional seed varieties.

Table 29: Common hybrid seed varieties in Karshi and Baddeggi
Source: Modified from (Maslaha Seeds, 2009)

Crop	Hybrid Variety	Properties	Remark
Maize (Hybrid)	a. HYBRID –SDM -2- Yellow	<ul style="list-style-type: none"> Yellow Seeded Hybrid Maize Resistant to Streak, Rust & Blight Semi Flint Grain High Yield Potential; 4-6.0 Tons/Ha Adaption to forest and savannah ecology 	Most of the hybrid varieties of maize are heavily fertilizer dependent Herbicide and insecticide dependent (against stem borers)
	b. HYBRID –SDM -1- Yellow	<ul style="list-style-type: none"> White Seeded Hybrid Maize Resistant to Streak Resistant to Striga Resistant to Weevil Semi Flint Grain High Yield Potential; 4-6.5 Tons/Ha Adaption to forest and savannah ecology 	
Maize (Open Pollinated)	SAMMAZ 11	<ul style="list-style-type: none"> Open Pollinated Maize Variety 	Fertilizer dependent Some (e.g. TZESR) are susceptible to downy mildew
	a. ACROS 97-TZL. SDM-3-Comp 1-W	<ul style="list-style-type: none"> Striga Resistant High Yield Potential White Seeded Suitable for Intercropping 	
	b. SUWAN 1-SR-Y	<ul style="list-style-type: none"> Resistant to Striga, Downy Mildew & other foliar diseases Yellow seeded Suitable for Forest & Savannah ecology 110-120 days maturity High Yield Potential, 2.5 3.5 Tons/Ha 	
	c. DMR-ESR-W	<ul style="list-style-type: none"> Early Maturing (90-105 days) High Yield Potential, 2 Tons/Ha 	

	<p>d. TZEE STWR W</p> <p>e. QPM SDM-4 – White</p> <p>f. DMR-LSR-W</p>	<ul style="list-style-type: none"> ▪ Extra Early, Striga Resistant, White Maize ▪ Adaptable to low rainfall dry seasons ▪ Yield Potential 1.5-2 Tons/Ha ▪ Open Pollinated Maize Variety ▪ Quality Protein Maize ▪ High in 2 essential amino acids; lysine & tryptophan ▪ High Yield Potential ▪ White Seeded ▪ Resistant to Downy Mildew ▪ Same as DMR-LSR-W ▪ Yellow seeded 	
Rice Upland (Hybrid)	<p>a. FARO 55 (NERICA I)</p> <p>b. FARO 56 (NERICA II)</p> <p>c. FARO 54 (WAB 189)</p>	<ul style="list-style-type: none"> ▪ Upland Rice Maturity ▪ Early Maturing (100 days) ▪ Good Weed Competitiveness ▪ Tolerance to Diseases ▪ Resistant to Lodging ▪ Good Cooking Quality ▪ Upland Rice Variety ▪ Early Maturity (90 days) ▪ Good Weed Competitiveness ▪ Tolerant to Diseases ▪ High Grain Yield ▪ Upland Rice Variety ▪ Early Maturity (100 days) ▪ Good Weed Competitiveness ▪ Drought Tolerant ▪ High Grain Yield Potential 	<p>Combines African rice (<i>Oryza glaberrima</i>), which is robust and adapted to local conditions and Asian rice (<i>Oryza sativa</i>), which is sensitive but high yielding (Cf.Cascio, 2005)</p> <p>Challenges</p> <p>Heavily fertilizer dependent</p> <p>Cost of fertilizer/herbicide</p> <p>Seeds & farmer rights</p> <p>On-going research</p> <p>Broken grain/husks(work in progress)</p> <p>Climate change</p> <p>Insufficient impact assessment</p> <p>Unstable environments</p> <p>Mainly for rain-fed upland</p> <p>Limited uptake by farmers</p>
Rice Lowland (Hybrid)	<p>a. FARO 52 (WITA – 4)</p> <p>b. FARO 44 (SIPPI)</p> <p>c. FARO 51 (CISADANE)</p>	<ul style="list-style-type: none"> ▪ Lowland Rice Variety ▪ High Yield Potential (3-4 Tons/Ha) ▪ Tolerant to Iron Toxicity ▪ Drought Tolerant ▪ Lowland Rice Variety ▪ Adaptation Irrigated Shallow Swamp ▪ Long Grain Type ▪ Days to Maturity; (115 days) ▪ Resistant to Blast ▪ High Yield Potential (3-4 Tons/Ha) ▪ Lowland Rice Variety ▪ Tolerant to African Rice Gall Midge 	<p>Challenges</p> <p>Diverse ecology</p> <p>Fertilizer dependent</p> <p>Herbicide dependent</p> <p>Cost of seed</p> <p>Availability of seeds</p> <p>Farmer's rights/seed companies</p> <p>Susceptible to pests (stem borers and birds)</p> <p>SIPPI is susceptible to iron toxicity</p> <p>Limited uptake by farmers</p>

Soyabean (Hybrid)	TGX 1448 2-E	<ul style="list-style-type: none"> ▪ High Yield Potential ▪ No Lodging ▪ Days to Maturity (110 days) ▪ Moderately tolerant to bacterial postule & cercospora leaf spot ▪ Shattering & Frog eye leaf resistant 	Fertilizer dependent
Sorghum (Hybrid)	SK 5912	<ul style="list-style-type: none"> ▪ High Malt Content 	Fertilizer dependent
Cowpea	<p>a. IT- 90K – 277 – 2</p> <p>b. IT -89KD – 288</p> <p>c. IT- 93K– 452 - 1</p>	<ul style="list-style-type: none"> ▪ Medium white seeds ▪ High yield (1.6-2.2 ton/ha) ▪ Non-photosensitive ▪ Medium maturity (75-80 days) ▪ Adaptable to Sudan savannah ▪ No lodging ▪ Moderately resistant to aphids, thrips, bruchid and nematode <ul style="list-style-type: none"> ▪ Large white seeds ▪ Photosensitive ▪ Late maturity (90days) ▪ Fodder and human consumption ▪ Other properties same as IT- 90K ▪ Medium white ▪ Non-photosensitive ▪ Early maturity (60-62 days) ▪ Can be planted all year round ▪ Other properties same as IT- 90K – 277 – 2 	<p>Challenges</p> <p>Only moderately resistant to pests</p> <p>Require insecticide (even though performs moderately without it)</p> <p>Fertilizer dependent</p>

4.15 Impact of Mechanization and Agrochemicalson *Fadama* Areas

In this section, the effects of mechanization and agrochemical use on *fadama* lands will be discussed. This is done with specific focus on the fragility of the *fadama* ecosystem. In general, the use of different power sources and improved farm tools and equipment to enhance productivity was found to be limited in both study areas. This is mainly due to the terrain and problem of access, cost and the limited availability of such equipmentto smallholder farmers in these communities. However, the use of agrochemicals (pesticide and herbicide) in both Karshi and Baddeggi was widespread. Just as agricultural mechanization has the potential to enhance production, it is also recognized that intensive and unregulated mechanization (e.g. excessive use of biological and chemical inputs of high yielding varieties, fertilizers and pesticides) can have negative consequences such as degradation of soil quality, loss of biodiversity, food toxicity amd pollution among others.

4.15.1 Impact of Mechanization on *Fadama* Areas

The extent of agricultural mechanization in both Karshi and Baddeeggi is relatively low as only a small minority have access to tractors and other farm machinery. The majority of the respondents rely on hand-tool mechanization of tillage, whereas a tiny percentage of the respondents use animal traction. While the farmers are eager to have assistance with regards to mechanization (especially tractor availability) which they view as important to increase area cultivation and agricultural output, they are not aware of any dangers associated with mechanization.

Mechanization has been helpful in increasing productivity and reducing social labour constraints (Binswanger, 1978). On the other hand, opponents of mechanization have pointed to its potential effects on employment (Barker and Cordova, 1978; Duff, 1978; Smith and Gascon, 1979), the high energy costs involved, the small size of smallholder farms, and finally doubts regarding the potential of mechanization to substantially increase production (Mrema et al., 2008). In both Karshi and Baddeeggi, mechanical power mechanization of tillage has a high appeal and this is the same in policy and academic circles where mechanization is generally seen as one of the surest ways of solving the low productivity of smallholder farmers. Those who call for caution in indiscriminate adoption of agricultural mechanization are considered to be cronies of the West who wish perpetual poverty on Nigerians (Odigboh, 1981).

However, any effort at mechanization should be aimed at developing existing technologies. Such an effort will have to deal with smallholder constraints such as farm size, the economic status of most small farmers who cannot afford costly machinery, knowledge deficit regarding machinery acquisition and operation, energy implications of mechanization and the seasonality of most smallholder agriculture (Verma et al., 1994). In fact, whereas mechanization might lead to reduced drudgery in the short term, it may actually increase it in the long run through increased weeding due to the resurgence of buried weed seeds. This makes low tillage more effective in weed control especially on small farms and reduces the potential risks to soil nutrient and structure associated with mechanization.

4.15.2 Impact of Fertilizer Use on *Fadama* Areas

Fertilizer use is prevalent among the farmers in Karshi and Baddeeggi because of problems of soil fertility, which is sometimes related to too much reliance on external inputs. However, the majority of the farmers are not properly educated on the appropriate fertilizer and correct dose of application. Furthermore, they have limited access to fertilizer on which they are continuously reliant upon, especially for crops such as maize and guinea corn.

Fadama areas are rich in underground water and soil moisture. The harmful effects of continuous use of fertilizer in *fadama* areas both on the soil and on underground water have not been sufficiently studied. However, the majority of farmers have reported decline in yield over years even with fertilizer application. The harmful effects of fertilizer are well studied and documented and range from disturbance of soil mineral ions, depleting of soil organic humus, increased risks of top soil loss, water logging, salinity and decrease in soil porosity among others. Given the nature of *fadama* lands, it cannot be ruled out that some of the fertilizer applied washes away into streams, rivers and water bodies on which the farmers depend for their drinking and cooking.

In addition to posing great danger to aquatic life (a sizeable number of *fadama* farmers raise fish in naturally occurring fish ponds on the farm), fertilizer washed into water bodies can increase risk of algae growth and eutrophication. The effect of Nitrogen fertilizer on the environment have been studied and it is understood that excessive use can lead to water and air pollution from nitrous oxides and oxides of nitrogen and ammonia, which can contribute in depleting the stratospheric ozone layer and lead to global heating (Byrnes, 1990).

4.15.3 Impact of Herbicides Use on *Fadama* Areas

Many of the chemicals used by the farmers are toxic and, depending on the level of exposure, can lead to poisoning and or possibly death. Paraquat (1,1-dimethyl-4, 4-bipyridyl dichloride) is a quick acting, non-selective, used widely around the world (about 130 countries) for weed control. Paraquat dichloride is a highly toxic compound in the US Environmental Protection Agency (EPA) toxicity class 1 and its use is restricted (Hamadi et al., 2004). It is also considered a bad actor chemical by the Pesticide Action Network (PAN). It has high acute toxicity and a potential underground water contaminant. It is also a suspected endocrine disruptor. It is also suspected that paraquat dichloride is a developmental/reproductive toxin (Lock and Wilks, 2010). Mild exposure of paraquat (through ingestion) results in renal failure, hepatic impairment, hypotension and tachycardia, whereas severe exposure can lead to haemoptysis, pleural effusion, and pulmonary fibrosis with deteriorating lung function (PANNA, 2002).

Atrazine, a member of the s-triazine family of herbicides, is considered to be a pervasive environmental pollutant (Cox C, 2001). It is restricted in many European countries (Germany, Denmark, Italy, Austria, etc.) and subject to strict restriction in others (UK and France). Atrazine is a major water pollutant (rain, fresh, marine and ground water) (Felding, 1992; Tasli et al., 1996). It persists in anaerobic or denitrified soils (Topp et al., 1995; Tasli et al., 1996) and some aquatic systems (Pratt et al., 1997) and thus poses potential harm to non-target organisms (Hussein et al., 1996). Studies on the carcinogenicity of atrazine are controversial and inconclusive but it is known

to have negative reproductive effects (Cox C, 2001). Research has also revealed its tendency for the development of resistance (Whitehead, 2002).

The post-emergence weed control herbicide, propanil, used by the bulk of the farmers in Karshi and Baddeggi is considered to be slightly toxic (Perera et al., 1999). It is also a potential water contaminant and causes acute toxicity in aquatic systems (Deuel Jr et al., 1977). Overexposure to propanil is known to result in damage and blood changes (WSSA, 1989). It is also toxic to birds (Rohm and Haas, 1991). On the other hand, Pendimethalin is slightly acutely toxic with moderate aquatic toxicity (highly toxic to fish and aquatic invertebrates) and a main contaminant in soil, groundwater, surface water and air (Kegley et al., 2007). The US EPA classifies it as possible human carcinogen (Ündeger et al., 2010). However, pendimethalin does not undergo rapid microbial degradation which minimizes risk of underground water contamination (USDA, 1990).

Glyphosate, the world's largest selling crop-protection chemical (Woodburn, 2000), is commonly used by farmers in both study areas. Glyphosate has been considered to be environmentally friendly owing to its biodegradation and strong absorption to soil (de Jonge and Wollesen de Jonge, 1999; Barja and dos Santos Afonso, 2004; Vereecken, 2005). However, it has been found to be slightly toxic and affects fresh and underground water. It is acutely toxic to certain aquatic species (fish) and even to humans in event of prolonged exposure (Mitchell et al., 1987; Servizi et al., 1987; Kreutzweiser et al., 1989; Payne et al., 1990). Glyphosate is also known to disrupt soil microbial communities (Carlisle and Trevors, 1988). Also, assumptions that it has low propensity for mobility and hence ground water contamination have been challenged by recent research which shows that glyphosate is susceptible to leaching (Flury, 1996), and can contaminate shallow aquifers (Vereecken, 2005).

2,4-D Amine has been widely used around the world for over 60 years and hence it is well studied. It is a WHO Class II moderately hazardous pesticide in the same class as paraquat (U.S. Environmental Protection Agency, 1988). It is acutely toxic to humans with negative health consequences (Shearer, 1990). Its carcinogenic effects are debated but it is known to be an endocrine disruptor (Extoxnet, 1994). Due to its low soil absorption, 2,4-D is highly susceptible to leaching (Environment Agency, 1997).

From the foregoing, the use of herbicides in both Karshi and Baddeggi (even if not excessive at the moment) poses significant environmental as well as health risks. These herbicides have the potential to alter the *fadama* habitat and destroy biodiversity (Freedman, 1995; Hayes and Laws, 1991). They similarly adversely affect microbial activity in the soil. Additionally, herbicides (for

instance, through drift) can have unintended consequences on aquatic animals and wildlife. For instance, Glyphosate and 2,4-D are known to have adverse effects on wildlife (W.H.O and F.O.A., 1997 ; Cole et al., 1998; Giesy et al., 2000; Hjeljord et al., 1988; Sullivan, 1990). Similarly, since herbicide application in these two communities is by broadcasting, there is a substantial threat to non-target plants which could significantly interfere with productivity. This is because some of these non-target plants serve other functions such as protecting the soil from erosion and nutrient leaching.

In addition to the toxicity of the herbicides used by the farmers in Karshi, to which many of them are oblivious, they report other harmful effects of herbicides observed over the years since they started to use them. This was explained by a farmer in Baddeggi:

There have not been any major accidents with regards chemicals. But we have realized that if the chemical pours on your body or makes contact with the skin it burns and it also itches. Also, during the mixing process, you notice immediate effect on your face – a burning sensation and pain the eyes. You have to wash your face. Also, whatever clothe you wore during the application process continues to itch your body, make you uncomfortable, until you change.

Many of the farmers have also reported increased weed resistance to herbicides and an increase in perennial weeds from year to year. According to one of the respondents in Karshi,

Each year, it seems the weeds are becoming more stubborn and I need to apply higher quantity of herbicide than I did the year before. I am running out of patience and money.

There is an apparent frustration with increase in perennial weeds especially in light of the financial capabilities of these smallholder farmers. According to White (1987), continuous use of herbicides can lead to the building up of sediments but also cause hardening of certain weeds. It can also have undesirable effects on soil pH and increase the danger of erosion due to excessive soil exposure.

An implication of the prevalence of resistant weed varieties in succeeding years means that there is decrease in food yield over years. This decline in yield and soil fertility is reported among farmers who have cultivated the same piece of land for a period of between 3-5 years. The decrease in yield may not be unrelated to the effect of herbicides and fertilizers on soil microbes and soil structure (Alexander, 1961; Selvamani and Sankaran, 1993; Das and Debnath, 2006; Zhong and Cai, 2007; Gu et al., 2008).

4.15.4 Impact of Insecticides Use on *Fadama* Areas

Aluminium phosphide is a metal phosphide used extensively for the protection of stored crops because of its efficacy, lack of persistence and harmless decomposition products (WHO, 1988). However, it is a restricted pesticide in the US because it is severely toxic to both humans and a wide range of living organisms (Bogle et al., 2006). Phosphine gas, a product of aluminium phosphide's reaction with water and stomach acids, can lead to the denaturing of oxyhaemoglobin and other enzymes important for respiration and metabolism (Meister, 1992). Mild inhalation/ingestion of phosphide has the potential to cause nausea, restlessness and abdominal pain. Symptoms of acute toxicity include diarrhoea, difficulty in breathing, cyanosis, hypotension, pulmonary oedema, respiratory failure, tachycardia and death (Chugh, 1991; Stewart et al., 2003). Because of its fast reaction with water, aluminium phosphide is soluble and non-persistent and poses no risk to ground water (Potter et al., 1990).

Actellic® is an organophosphorous pesticide containing 2% pirimophos-methyl as the active ingredient. If it enters water body through run-off effect, it has toxic effects on aquatic organisms (Oluah and Mgbenka, 2004), especially fish (Omoregie et al., 1990). Research has shown that actellic or its active component pirimiphosmethyl also affect the growth and reproduction of some soil bacteria and fungi, fixation of atmospheric nitrogen, nitrification and overall soil metabolic activity (Čerňáková et al., 1992). Monocrotophos is also a systematic organophosphate pesticide commonly used for pest control. However, it is very toxic with known danger to agricultural land and biotic (Nemcsok et al., 1987; Thangnipon et al., 1995). It is also a water contaminant posing a particular risk to fish (Mahttiessen et al., 1995; Storm et al., 2000). Monocrotophos also has mutagenic potential as well as being genotoxic to aquatic organisms (Banu et al., 2001).

The insecticides used in the *fadama* areas have obvious health effects as a result of their toxicity. They also have negative environmental consequences such as the threat they pose to non-target species, such as birds and fish. This corroborates previous findings on the effects of insecticide (Johnson, 1972). Also, because insecticides persist in the environment, they can find their way into animal tissues and pass through the food chain thereby affecting the survival and productivity of plant and animal populations. Furthermore, insecticides lead to reduction in crop yields when they kill important insects that help in pollination (Johansen, 1984; Misra et al., 1988; Perveen et al., 2000). Insecticides are also known to negatively affect amphibians (Boone et al., 2004). Generally, therefore, pesticides disturb the ecosystem and the balance between pest and predator that exists in the natural food chain – a relationship well understood and utilized by

traditional farming societies such as those in the *fadama* areas. Agricultural extension can play a vital role in re-educating the farmers on natural balance instead of reliance on insecticides.

Other more direct effects of increased insecticide use also include resistance to insecticides by certain varieties of insect pests. Research has amply shown how different pests adapt to insecticides targeted at them by surviving exposure at rates that previously controlled them. The species that survive even exposure eventually replace the susceptible ones. In a study by Brown, over 250 species resistant to chemicals were identified in different parts of the world (Brown, 1967; Brown, 1973).

In conclusion, therefore, even though the use of pesticides is below the minimum recommendation, yet it is widespread and continuous/increased use will have many long lasting and dire consequences. Nigeria is said to annually consume about 125,000-130,000 metric tonnes of pesticides (Asogwa and Dongo, 2009). This is particularly a potential threat in *fadama* areas where water retention level (both surface and underground) is high. It is generally agreed that 70% of pesticides is either retained in the soil or drained into water bodies – only 30% is actually utilized (UNEP, 1992). Similarly, pesticide retained in the soil could accumulate over years and be translocated by arable crops, leading to increased health hazards (Dung and Dung, 1999).

4.15.5 Factors Increasing Risks Related to Agrochemicals Use in *Fadama* Areas

The use of agrochemicals in both Karshi and Baddeeggi is widespread as already shown even if use is not intensive. The threat of agrochemicals - both to the ecosystem and to human health - is real but not adequately studied in Nigeria, especially in the *fadama* areas. The risks of poisoning from chemicals use are high among the farmers in Karshi and Baddeeggi for a number of identified reasons. Firstly, the level of literacy among these farmers is very low with only a handful of them able to read and write. As shown in table 30, 61.7% of the farmers do not have any formal education while only 23.4% have had primary school education. Hence, they cannot read safety instructions on chemical containers.

	Karshi			Baddeggi	
		Frequency	Percentage	Frequency	per cent
Education	No formal education	29	61.7	7	33.3
	Up to primary school	11	23.4	10	47.6
	Up to secondary school	7	14.9	4	19.1
	Total	47	100.0	21	100.0
Use of protective clothing	Yes	8	48.9	13	61.9
	No	39	51.1	8	38.1
	Total	47	100.0	21	100.0

Table 30: Level of education and use of protective clothing among Karshi and Baddeeggi farmers

Secondly, most of the farmers interviewed (83.0%) neither have nor use personal protective clothing as recommended when applying herbicides and insecticides. The general attitude to protective clothing is indifference and many farmers are exposed to high doses of chemicals during application as explained by a Baddegi based extension worker:

To be honest with you, they [the farmers] mostly have a nonchalant attitude towards the use of personal protective clothing. They don't use protection and it appears some either don't know or don't care. There is a popular belief among some farmers that milk is an antidote to herbicides poisoning. An extension worker introduced them to it and it is now popular among many farmers. Sometimes, the milk induces vomiting.

Thirdly, there is a shortage of extension workers to educate these farmers on the proper means of application and protection from these chemicals. Karshi, a village of over 20,000 has only two (2) extension workers, whereas, none was encountered in the Baddegi *fadama* farming community. As a result, the level of awareness regarding the dangers associated with poor use and exposure to chemicals is very low with 61.7% of the farmers ignorant of the hazards of chemicals, while only 9% agreed to being aware of the risks involved. A farmer in Baddegi explained the situation thus:

We have had cases of pesticide poisoning here but it is not very prevalent.... a farmer slept with the chemical [photoxin] in the room. He was gradually inhaling it and before morning he was dead. Also, we use insecticides for our conpea because of too many insects. If you don't use it, then the yield is reduced. Because of that, you see all sorts of chemicals in the market- some are actually for cocoa, like DDT. They are very harmful but they are also very cheap. The bad ones are always cheaper and some farmers go for those ones and the slightest misuse can be very dangerous... it has killed so many people... and it is even dangerous for the plant because it burns the conpea! And some of the chemicals have very strong and nauseating smell/odour. When you inhale it for long... your stomach starts to turn and you have diarrhoea.

Fourthly, disposal of chemical containers is indiscriminate and unsafe. In both Karshi and Baddegi, chemical containers are left on farms or used for storing water and food supplies such as oil. Fifthly, the method of chemical storage is equally unsafe as it is often kept in the same room where the farmers sleep. In Baddegi, for instance, there have been reported deaths due to prolonged exposure to insecticides. Sixthly, the use of inappropriate and often poisonous chemicals by farmers is common as insecticides meant for crops such as cocoa is used by rice and maize farmers because these chemicals are cheaper and available in the market. Some of these chemicals are highly toxic and banned in Nigeria. Furthermore, the presence of contaminated and adulterated agrochemicals is not uncommon. Finally, drug regulation and control in Nigeria have

centred more on pharmaceutical drugs and not on agrochemicals. Recently, however, The National Agency for Food and Drug Administration and Control (NAFDAC) has stepped up its campaign on adulterated agrochemicals as a result of food poisoning reported in some parts of Nigeria.¹² In general, there is inadequate knowledge on the correct use of agrochemicals and the effects of these chemicals in *fadama* areas have not been fully studied.

The use of chemicals among many farmers appears purely random and arbitrary and a farmer in Karshi explained:

We don't know the names of the chemicals ourselves. When we go the market where the herbicides are sold, we ask for chemicals that completely kill the weed together with its root. Then the seller will give it to us. Or, sometimes we ask for chemicals that will kill the weed that grows with our rice after we have already transplanted. The seller will give us something suitable for what we described.

Many of the farmers are largely unaware of the short and long term harmful effects of fertilizer on the soil and are only vaguely aware of the dangers of herbicides/insecticides. The farmers report observed clinical symptoms associated with exposure to chemicals (e.g. skin inflammation/itching, burns, pain in the eyes, dizziness, stomach upset and diarrhoea) but do not always link them to chemicals use.

The method for prescribing the chemicals to farmers is equally arbitrary, done by the retailers based on what type of weed a farmer says are growing on his/her field. This is often done without inspection of the stated problem. Additionally, there is the problem either of over-utilization or under-application of fertilizer and herbicides. In the case of the former, there are reported cases of damage to crops and poisoning in humans. This problem is compounded by indiscriminate storage and disposal of chemical and chemical containers. Many of the farmers store these chemicals in the rooms where they sleep and a few deaths have been reported as a result thereof.

There is no study that details the effects of the different chemicals on the people and their habitat and statistics are hard to come by. However, records from the community hospital show the prevalence of illnesses associated with chemical use: diarrhoea, stomach ache, skin irritation, nausea, headache and death from over exposure to fumigants.

¹² Chemicals banned by NAFDAC include the following pesticides: aldrin, binapacryl, captafol, chlordane, chlordimeform, DDT, dieldrin, dinoseb, ethylene dichloride, heptachlor and lindane, parathion, phosphamidon, monocrotophos, methamidophos, chlorobenzilate, toxaphene, endrin, merix endosulphan, delta HCH and ethylene oxide.

4.15.6 Impact of Hybrid Seeds Adoption on *Fadama* Farming

Despite its appealing characteristics such as early maturity, many of the farmers are sceptical of hybrid seeds. Major reasons for the relative low success of hybrid seeds among smallholder farmers in Karshi include the following: first, many of the farmers do not have the financial resources to spare on hybrid seeds. Thus, they prefer to save seeds for use against the next farming season. As indicated by some of the farmers, they find it difficult to buy seeds from the market as they are used to the practice of selecting and saving their own seeds. Secondly, the farmers are aware that the success of hybrid seeds is tied to the availability of external inputs especially fertilizer and herbicides.

Also, the use of hybrid seeds is endangering local varieties as explained by an extension worker in Karshi:

For instance, when they are given improved rice (Nerrica rice or Wita 4), they are told that it requires fertilizer for maximum yield. So they follow the instructions. Unfortunately, they leave their local rice unattended to and without care or fertilizer. Naturally, the improved one performs better while the local one does not. The failure of local varieties means that they can gradually disappear. But if the land where they planted the local rice is fertile, then it also performs as good as the improved variety.

Whereas hybrid seeds perform better than local varieties under the prescribed circumstances, many of the smallholder *fadama* farmers prefer to use local seeds as it has become increasingly difficult for many of the farmers to afford fertilizer and herbicides. Similarly, many of the farmers are not aware of where to get hybrid seeds and even where they are, they are reluctant to go there especially if it is too distant from them.

Even more important, however, is the insight that many of the farmers are not as concerned about maximum yield as about stability. Farmers prefer a variety that can withstand environmental stress with the least amount of input and are only willing to go for higher yielding varieties if they meet this standard or if the farmers are guaranteed access to fertilizer and herbicide. This counters popular assumption that agriculture and indeed smallholders are all about yield maximization or that the success of agriculture is measured in yields. Findings from this research indicate that from the perspectives of many farmers, stability is perhaps more important than short-term yield. This stability is often ensured by traditional resource management techniques such as low tillage.

4.16 Assessing the Sustainability of *Fadama* Agricultural Systems

For an agricultural system to be considered sustainable, it has to meet certain criteria which include: (1) economic viability (2) ecological soundness: low use of external input and more reliance on renewable resources; natural system protection through natural resources regeneration; and (3) social value: ethical and socio-communal benefits through improved quality of life (Hinterberger et al., 2000; von Wirén-Lehr, 2001). Importantly, agricultural sustainability does not equal a fixed and unchanging set of practices but includes the ability of a farming system to adapt and cope with change and uncertainty on a continuous basis as well as deal with unexpected events (Pretty, 1997; Hinterberger et al., 2000).

It is not often the case that agricultural systems meet all these requirements all at once. Transition to agricultural sustainability is sometimes a gradual process. Hence, whereas some systems are wholly sustainable, others are only moderately sustainable. There is no precise word for sustainability in Hausa but the basic idea and tenets expressed in the concept are encapsulated by the phrase *noma mai inganci*, which was used frequently throughout the research by farmers to refer to a type of farming that is healthy and beneficial both economically but also socially and environmentally. Based on the three criteria above, it is possible to determine the sustainability of *fadama* farming considering the basic elements of that agricultural system already discussed. The evaluation below is done with a special focus on the ability of *fadama* agriculture to manage risk, adapt to changing circumstances, build on existing system and create new opportunities (Holling, 1996; Berkes and Folke, 1998; Peterson et al., 1998; Gunderson, 2000; Carpenter et al., 2001).

4.16.1 Economic Viability of *Fadama* Agriculture

The argument regarding the productivity of smallholders and their ability to feed the world continues to generate debate with some insisting that the solution to the world's food crisis lies in industrial agriculture and green revolution in developing countries, especially Africa, where the food problem is endemic (McGloughlin, 1999; Le, 2005; Borlaug, 2007a; Borlaug, 2007b; Borlaug and McPherson, 2008; Pennisi, 2008; Pollack, 2008a; Richardson, 2008; Zahn et al., 2008). On the other hand, many have questioned not just industrial agriculture's ability to feed the world but also its sustainability over time (Soule and Piper, 1991). The argument against industrial agriculture is both for environmental issues such as pollution (Mallin, 2000; Ferber, 2001; Staver and Brinsfield, 2001; Rabalais et al., 2002; Smith et al., 2003) but also for ethical, social and cultural reasons (Then, 2000; Andrews, 2002; Jordan, 2002).

In Nigeria, agricultural productivity is generally considered to be low and below the optimum possible, mainly for reasons ranging from biophysical, socio-economic and institutional (Goldman

and Block, 1993; FAO, 1996; Adedipe et al., 1997b; Spencer and Kaandaneh, 1998). This is especially the case for smallholder farmers in rural areas whose productivity is constrained by many natural, socio-economic and cultural factors. Thus, in order to appreciate the output of the *fadama* users and smallholders spread across Africa, these factors should be taken into account.

Rice is the most important crop grown by the predominantly women farmers of Karshi and the men of Baddeeggi. That rice is the exclusive domain of women in Karshi represents a significant shift from many communities in Nigeria where rice production is considered as an exclusively male enterprise. The importance of rice for these farming communities is better understood within the context of the rice ecology (i.e. *fadama* lands) and land availability to these farmers. *Fadama*, because of its water retention capacity (lowland and floodplains) and high soil nutrient value is ideal for rice production. In fact, about 70% of all rice farmers in Nigeria operate within the *fadama* ecology (Erenstein et al., 2003). Furthermore, rice is a major part of the diet in many parts of Nigeria and hence serves both the nutritional need of the *fadama* farmers but also as a source of income.

In general, the average rice yield for the smallholder households in Karshi is between 1.5-2.3 t ha⁻¹ of paddy rice. However, the farmers note that yield differs from year to year depending on rain volume and the availability of fertilizer and herbicides. The average rice yield in Baddeeggi is slightly higher (about 2.5 t ha⁻¹), with peak yield of up to 3.4 t ha⁻¹. The higher yield in Baddeeggi is as a result of more organized irrigation systems (the irrigation network in Baddeeggi is elaborate as described above) and access to inputs and extension services from the agricultural research institute. An extensive yield analysis study carried out by Fagade (2001) in Baddeeggi confirms this finding and shows a decline in yield in this area between 1954-1996 as a result of decline in management and technical assistance and depletion of soil nutrient. With proper management techniques, potential rice yield in Baddeeggi is estimated to be up to 7 t ha⁻¹ (ADP, 2009).

Hence, rice farming in *fadama* areas holds immense potential to meet the growing annual rice demand in Nigeria which is estimated at over 4.1 million tonnes a year (Erenstein et al., 2003). Nigeria imports 1.9 million tonnes of rice annually at the cost of over USD 500 million (USDA FAS, 2003). This is because domestic rice production in Nigeria is abysmally low both with regards quality and quantity (Erenstein et al., 2003).

Maize (*masara*) is another important crop for the vast number of respondents. It is an important part of the diet as well as rural economy. It has been described as one of the most important cereal crop in Nigeria (Agboola, 1979). Maize is processed and its flour is the main source of food for the people in Karshi and Baddeeggi (*tummo*). It is also eaten boiled or roasted and is also an important part

of livestock and poultry feed. Unlike rice which is mainly grown as a sole crop, maize in these two villages is intercropped with other crops such as cowpea, sorghum, and groundnut. The average maize yield per ha in Karshi and Baddeggi is about 1000kg/ ha⁻¹-2, 500 kg/ ha⁻¹(ADP, 2009).

Sorghum (*dawa*) is an important cereal cultivated also for food as well as for economic purposes. It is either processed into flour and used for food or sold in the market. It is also used in making the widely consumed local brew (*burkutu and kunun zaki*). The yield of sorghum in Karshi and Baddeggi is similar to that of maize in both areas (about 1000kg/ ha⁻¹-2, 500 kg/ ha⁻¹). The importance of sorghum in the diet and economy of smallholders has been well researched(Selvaraj, 1980; IAR, 1984; Ajayi, 1989).

Yam (*doya*) is predominantly grown by male farmers in Karshi. None of the respondents in Baddeggi cultivated yam. Yam is grown both for economic reasons and also for family consumption. Yam production is generally labour intensive involving land preparation, heap making, planting, weeding, staking and harvesting. This explains the relative increase in the price of yam over the years in light of diminishing rural labour and the cost of inputs (Ike and Inoni, 2006). Most yam farmers in Karshi report an average yield of between 30-40 t/ha⁻¹. Yield varies depending on the amount of fertilizer available to the farmer.

Evidence from both Karshi and Baddeggi show that between 60-75% of cereals and tuber crops produced are consumed over the course of the farming season. Usually, it is the man's responsibility to feed the family and provide for its needs. However, the reality often means that the wife, especially in polygamous homes, significantly contributes in that regard through providing for her children. Hence, the husband and the wife jointly support the family. 25-35% of farm produce are sold at different times of the year to support the family and ease social pressures. An average of 5% of total farm output is saved for use as seeds for the next farming season. The percentage of what is sold is higher (between 40-67%) for vegetables and fruits. Also, the percentage of what is sold is higher for farmers with over 1ha of land.

Produce from the farms are mostly distributed through the market. Both communities observe regular market days (usually every other fourth day of the week) during which farm produce are sold mostly to marketers both from nearby and far away cities who buy farm produce off the farmers to re-sell in the cities. The market in Karshi is largely informal/semi-formal and farmers relate directly with potential buyers and negotiate prices for their produce. Usually, a price cap for different crops is agreed upon by the farmers through cooperatives and farmer associations. Unlike in Karshi, the market in Baddeggi is developed as Baddeggi is a well-known rice producing

community. In the past, government was involved in buying produce from farmers. Also, the government funded rice mills in Baddegi in order to promote the rice market. In both communities, farmers often take their farm produce to adjoining villages on market days and a few take them to cities to sell in bigger city markets. However, this is often cumbersome and many farmers are discouraged especially where there is no guarantee that they would actually sell their farm produce. Farmers also trade among themselves either by way of barter trade or monetary exchange.

The overall annual yield in *fadama* agricultural systems is good even if not optimal. Agricultural 'experts' attribute the deficit in production mainly to lack of sufficient access to inputs (fertilizer, herbicide and mechanization). For instance, the rice yield of the farmers is considered abysmally low as optimum yield, under the recommended techniques and with adequate inputs, yield per hectare could be between 5-10 t/ha⁻¹. However, subject to optimum soil conditions, good crop management techniques, average maize yield could be between 5, 000- 6, 000 kg/ ha⁻¹ (Kowal and Kassam, 1973).

On the whole, it should be noted that many of the respondents in Karshi and Baddegi consider themselves to be producing below the optimum levels possible for reasons such as environmental limitations, lack of institutional support, land tenure obstacles, lack of sufficient inputs and the labour associated with smallholder farming. This is in line with numerous researches which point to the relative low output of many smallholder farmers (Spencer and Kaindaneh, 1998; Adedipe et al., 1997a; FAO, 1996). Thus, farmers barely produce enough to take care of their subsistence and immediate family pressures such as paying of school fees for their children. Respondents are convinced that they can improve their output given the necessary conditions and support.

Thus, it is to the credit of the *fadama* farmers that they are able to produce as much given little external input, harsh and unstable environmental conditions and little institutional support. The ingenuity exhibited by the farmers in utilizing traditional methods, most of which are sustainable, to produce enough food to feed their families and surplus to sell reinforces the immense potential of agroecology to meet the food needs of developing countries if properly managed (Stockdale et al., 2001; Mader et al., 2002; Pimental et al., 2005; Cox et al., 2006; Pearson, 2007). With less capital and support, therefore, these farmers produce more per acre than many commercial farms.

In fact, the bulk of the basic food (maize, vegetables, fruits, cassava, and yam - among others) that feeds Nigeria is largely produced by smallholders like those in Karshi and Baddegi, using mostly traditional methods of production. For example, the farmers in Karshi produce enough for

subsistence and surplus to supply to the city of Abuja. Thus, every four days, retailers from the city flock Karshi and cart away tomatoes, vegetables (e.g. spinach), eggplant, yams, onions, banana/plantain, sugarcane, maize and sorghum at very low prices either to re-sell these in major city markets or for family consumption. According to one farmer in Karshi:

Yields fluctuate depending on the rain and soil fertility but there it can never be said that we are starving and there is no food to eat at any given time. Some years the yields are very good but even when it is not, there is enough to feed the family. As you saw on the market day, lots of people come from Abuja and faraway places to buy food from here and sell in the cities.

In addition to grains, vegetable and fruits, Karshi farmers have increased production of short cycle animals (sheep, goats, grasscutters), poultry (chickens, ducks and turkeys) and most importantly fish, which has become a major earner for the farmers because of high demand in the cities among the popular *point-and-kill* fish roasting spots that can be found spread across Abuja. Consequently, smallholder farming in both Karshi and Baddeeggi villages is not just a source of income; it also provides employment and raw materials and market for other sectors of the economy.

In general, smallholders already contribute substantially to domestic food production in Nigeria. Their contribution both to the GDP and to food security is well documented. Smallholders drove the country's economy and contributed over 60% of its GDP in the 1960s through the production of export crops such as cotton, groundnut, rubber, hides and skins. These smallholders also account for over 70% of Nigeria's export and supplied over 80% of its domestic food demands (Alkali, 1997; Lawal, 1997). They achieved this through reliance on simple traditional tools and indigenous farming systems. An official of the Agricultural Development Programme in Minna described smallholder potential in this way:

If you go round the state, even here, you see the land... Niger state alone, given all the support and impetus, can feed this country and even export in terms of rice production. Our farmers have never been encouraged to produce. No one would want to produce at a loss. So, many farmers invest in alternative crops from which they can get better returns for their families and children.

Results from Karshi also confirm findings by Wiggins (2000) which question the reliability of national statistics on agricultural growth. Most of the data, he argues, are mostly intelligent conjectures which often underestimate production and exaggerate decline in productivity. Also, they ignore the influence of population growth, global falling prices and environment limitations such as drought on productivity. Drawing from 26 case studies in West Africa (mostly centred on smallholders often ignored in national statistics), Wiggins (2000) shows how agricultural

performance in these countries has not significantly declined but has actually matched population growth from the 1970s to the 1990s. Smallholders in rural areas maintain reasonable productivity levels despite increasing pressure on natural resources. The success of *fadama* farmers (as seen in their levels of income) is also related to their proximity to major cities (Abuja and Bida). This further substantiates Wiggins (2000) findings that access to market is essential for agricultural development.

However, despite its huge contribution, smallholder productivity in its present form is struggling to meet the food needs of a growing population and hence the country relies on food imports. Thus, smallholders need help because they are not producing to the optimum. Smallholder productivity can be enhanced through structures that encourage, support and protect smallholders in rural areas. They have often been disregarded, marginalized, and displaced by big development schemes because they were regarded as unproductive and inefficient.

4.16.2 Ecological Soundness of *Fadama* Agriculture

As discussed earlier, risk management and resilience are vital in *fadama* agriculture. It is able to absorb change and shocks without massive damage to the whole system. To achieve this, they draw from indigenous knowledge system of changing physical conditions (e.g. rainfall) and respond accordingly. This knowledge is reflected in the management of soil and water resources which is done to maintain fertility and reduce degradation.

In soil management, the use of traditional methods such as minimum tillage (e.g. rice broadcasting into existing stubbles) not only preserves soil integrity, but also reduces risk of erosion, improves soil structure, and increased biological activity among others. It also reduces cost of production. According to a farmer in Baddeggi,

Rice broadcasting saves me labour and with all other things in place, it actually results in very good yield. It is even more helpful to broadcast because of the type of soil and the type of weeds growing there. Some soils are unstable and digging them up will only further weaken them, so it is good to broadcast. Also, whenever I broadcast it reduces the number of times I have to weed.

Ridge tillage, a very popular farming practice among *fadama* farmers, is a very practical example of minimum tillage that helps in soil conservation, weed management and increased yield.

In addition to these methods, inexpensive and sustainable soil conservation methods such as the use of cover crops (e.g. cowpea, velvet and soy beans) and green manure to increase nutrient availability (nitrogen and phosphorus), improve soil quality through increased organic matter, control weed and enhance soil structure are all common practices in Karshi and Baddeggi. It is

often the practice in Karshi for farmers to use green manure in crop rotation where cereals and roots are rotated with legumes. In the same way, cover crops are commonly used in mulching by the farmers as residues and crop parts of cover crops are left on the farm as weed control, protection against erosion and moisture preservation strategy.

Cover crops are often used with animal manure such as cow manure, poultry droppings, and house refuse (*taki*) to increase soil fertility and organic matter. In addition to its long lasting effect on soil, animal manure is readily accessible as the practice of integrated farming is widely practiced in both communities. Using low cycle animals such as goat, sheep and poultry, the farmers not only meet economic pressures but run a sustainable integrated system where plant residues are used to feed the animals and in turn their faecal matter is harvested and used on the farm. This system is efficient and profitable to most of the farmers and offers alternative means of livelihood. It also minimizes use of fertilizers and other chemicals, minimizes pollution and maintains soil fertility.

Other soil conservation practices like mixed cropping have resurfaced in many parts of Nigeria after the initial emphasis on mono-cropping during the Green Revolution era. This important traditional farming system is cost efficient and high yielding. Mixed cropping also increases on farm biodiversity and helps to suppress weeds.

Many of the traditional agricultural practices used by *fadama* farmers are efficient in energy use as they rely on limited anthropogenic energy inputs to produce. In fact, given the energy utilized, the productivity of *fadama* users is good compared with the high energy demands of modern agricultural production. *Fadama* agriculture gives the farmers independence in a virtual cycle and if all conditions are met, productivity could be very high. However, like all such farming systems (Bayliss-Smith, 1982; Glaeser and Phillips-Howard, 1983) *fadama* agriculture often has low level of absolute output.

Traditional pest management in Karshi and Baddeeggi involves a series of sustainable actions already described above which include such methods as crop rotation, careful planting and harvesting regimes, burying and burning of residues to kill off pests and the use of ridges. Other methods include the use of heat from cooking places to keep barns dry and repel aphid and weevil attack, the use of scarecrows to keep off birds attacking rice farms and the use of other medicinal plants to treat seeds and crop plants against insect infestation.

Much of the traditional water management in the *fadama* areas is sustainable even if not adequate, especially during the dry season. Aquifers recharge seasonally and thus sustainable over long

periods of time. Also, traditional irrigation methods do not significantly disturb the valley morphology/structure nor result in serious pollution of aquifers. The various irrigation systems are designed such that water is effectively channelled not just to farms close to the river but those that are far away from it through the use of canals and furrows. Water loss is minimized in the canals and furrows by surfacing the canals with water proof materials like animal hide or plastic in recent times.

The frequency and amount of water withdrawal from shallow wells (using skin bags – *guga*) is done to ensure long-term availability and hence sustainability. Also, the timing of water withdrawal is important as most of it is done in the evening and when the sun's heat is not intense. This allows for aquifers to recharge and also reduces water loss due to evaporation and farmer dehydration.

The use of the *shaduf* system in irrigation indicates not just a time tested practice but more so a harmonious management of environment. In addition, traditional irrigation systems in Karshi and Baddeggi were generally simple and therefore cost efficient and adapted to the people's way of life. Equally, because of the labour demand involved, traditional irrigation systems generated employment opportunities. Another important strength of traditional irrigation is its role in social cohesion. In Baddeggi, for instance, responsibility for the irrigation system is shouldered by the whole community under the supervision of the village chief. In general, the traditional irrigation systems in both communities were sustainable and relied on gravity for water to transport water over long distances and within the farm. *Fadama* water management is also resilient and able to adapt to competing interests (e.g. the demand for water from Fulani herdsmen). The adoption of China modelled irrigation pumps by farmers shows their dynamism and willingness to experiment with new technologies especially those that they consider compatible with their farming systems and geography.

Fadama farming relies on prudent use of available natural and renewable resources for the most part and protects the integrity of natural systems through regeneration of natural resources. It exploits the synergies and complementarities that exist in the ecosystem – it provides a holistic as against a fragmented perspective of the agroecosystem. This finding has been confirmed by similar research in the area (Tarhule and Woo, 1997).

In addition to these sound ecological farm management practices derived from an intimate understanding of the *fadama* environment by its users, *fadama* agriculture is equally sustainable because it allows for diversification as discussed earlier. It is also flexible in so far as it incorporates both on-farm and off-farm activities in order to stabilize itself especially in light of disturbances

(such as pressures from climate change and human activities). An additional quality of *fadama* flexibility is its capacity to self-organize through reliance on a flexible network between farms. An example of this is the labour relationship that exists between farms through the practice of *gaiya*, whereby farmers mobilize and help each other on a rotational basis. However, it is not only labour that is shared but also skills and knowledge. According to Scheffer et al., (2000), such networks create flexibility in problem solving and a balance of power among interest groups thereby reducing the tendency of large organizations to develop rigidities which eventually precipitate crises (Holling and Meffe, 1996; Holling, 2001). The capacity to self-organize is also reflected on the relative autonomy of *fadama* agricultural systems from external institutions. Whereas there is knowledge sharing between the two through extension and inputs supply, this was found to be limited and insufficient. Thus, *fadama* systems rely a great deal on local information, knowledge and expertise and this is even truer in the wake diminishing government support.

An important component of both sustainability and resilience is decreased dependence on external inputs. In the case of *fadama* agriculture, much of the system depends on internal nutrient cycles and there are elaborate traditional management techniques for improving soil fertility, managing water resources and controlling pests. However, alongside these sustainable traditional management practices in Karshi and Baddeeggi exists mixed system (often employed together with traditional systems) that is dependent on synthetic chemicals. This corresponding system compromises environmental sustainability of traditional system and threatens its continued existence. In general however, agrochemical use is extensive but not intensive and depends on a complex but interrelated factors as explained by a farmer in Karshi:

There are some areas that you farm year in year out and it never tires. But others need to be constantly treated with fertilizer. The latter is called kasa mai zezeya (alluvial soil) – but even among alluvial soils there are two types – the first keeps a reasonable moisture level (lema) and the other doesn't. Some soils have are silty at the top but have clay under – the silty soil drains water and is dry but the clay underneath retains water – this is not good for crops that require only minimal moisture. If you know this then you can go round the problem through careful planning. For such soil it is good to plant there very early in the rainy season and apply lots of fertilizer so that by the time the rains come, the crop has already take root or you plant at the end of the rainy season when the rains are finishing but the soil is still relatively moist but not over-clogged.

Another important component of resilience and sustainability relates to the adaptive ability of both the system and the individual farmer. As shown above, *fadama* systems are flexible and resilient.

Equally, individual farmers in the management of resources reflect this learning ability as seen in the process of experimentation and diversification and the feedback from the processes which shape future action. Certain aspects of the system are adopted, modified or entirely discarded depending on the farmer's interpretation of relevant signals from changes in the environment and incorporate them into the farm system.

4.16.3 The Social Value of *Fadama* Agriculture

Agriculture has come to be acknowledged for the role it plays beyond the delivery of food and economic benefits. Instead, it is encompassing of other socio-cultural benefits such as environmental protection and landscape, wildlife management/preservation, rural cohesion, preservation of cultural heritage and identity and entertainment (Aldington, 1998; Dobbs and Pretty, 2001; Harwood, 2002b; Moyer and Josling, 2002; Jongeneel and Slangen, 2004). This has been referred as agricultural *multifunctionality*. Writing on African agriculture, Fairhead and Leach (2005) noted that much of the discussion on African agriculture has been done in abstraction and exclusion of social relations of those who do it. Even when these issues have been discussed, as in the years few decades, it has been within the framework of much earlier inadequate traditions. However, in order to understand agricultural production, investment and technology in Africa as well as markets, the social and cultural elements that underlie African farming (Scoones, 2001).

For the farmers in Karshi and Baddeeggi, farming is not just a means of livelihood but more importantly, a means of creating meaning. The cosmology of the people is built around agriculture and thus it extends beyond simple production to embrace social, cultural, sentimental and religious values. For instance the strong attachment to land in Karshi and the unwillingness of farmers to move even in cases of erosion or road expansion is tied to family history (stories and legends) and personal history. This dimension has not been adequately studied in Nigeria and agricultural policies neglect it.

The farmers express and understand *fadama* farming as a cultural norm and sometimes even as a religious duty. They cherish the methods and practices involved in the exercise of farming as a heritage from their ancestors and as a gift from Allah. In other words, they feel a bonding with the land as it encapsulates their history as well as their aspirations. Many of the cultural practices carried out in *fadama* farming (land preparation, planting, watering, weeding, harvesting and even marketing of farm produce) represent this collective history and knowledge. *Fadama* agriculture and *fadama* areas thus define the people and give them meaning (*ma'ana*). The sentimental attachment of *fadama* farmers to land and agriculture was described by a farmer in Karshi:

Farming (noma) is our life and my father was a farmer and he taught me everything I know. He also learnt from his father and so on. Every family land has its own story and sometimes even some trees on the farm have their own story. So the land is special, it is the place where my umbilical cord was buried. So my heart is tied to it, it is all I've got and so I treat it with respect because it is always there for me and my family and it is what I will pass on to my own children.

An important function of agriculture in both communities relates to social cohesion and by extension, the preservation of both communities. Festivals are structured around agriculture – for example there are festivals to herald the beginning of the farming season and to usher in the harvest time. These festivals bring community members together to celebrate the productivity of the land as well as the blessings of Allah during the farming season. Also, there are agricultural fairs (*wasan gona*) meant to showcase the best crops/animals from a particular season and reward farmers who show innovation in crop/animal improvement. These fairs (shows) that have been part of the lives of indigenous communities in Nigeria for centuries have been adopted and commercialized by the government to help showcase the agricultural potentials of farmers and also attract investors. The Nigeria national agricultural show held in Abuja at the time of this research had, among others, the following objectives: to contribute to the country's drive to achieve food security, to promote value addition to Nigeria's agricultural produce and improve marketing outlets, promote appropriate skills among farmers, to encourage and attract young people onto the farm and to support gender based activities to help women and rural dwellers (NAFN et al., 2009). In addition to agricultural fairs, agricultural markets hold a social value as they more than just an avenue for economic dealings but also for social interaction. Farmers (those from village centres and others from the hinterland) interact with each other and share knowledge and ideas. The presence of entertainers (*masu wasa*) is an important aspect of market days. In addition to the above, the maintenance of common property such as irrigation systems brings farmers together especially in Baddeeggi where the irrigation system is developed and extensive.

The social also shapes the interaction of *fadama* farmers both with government and donor organizations. For instance, farmers' adoption of hybrid seeds is based on their market value. They are never used for the making of local brews (*kunun zaka*) or local food (*tunwo*) as explained by a farmer in Karshi:

...we have tried the improved grains, for example, in the making of our local brew and drinks and it is awful. It doesn't taste good at all. But the local one is superb especially for

burkutu (local alcohol). The improved one is also not good for food (tumo) because it doesn't taste the same as the local variety (dan kasa).

However, this is not always the case as some vegetable farmers preferred improved varieties as this Karshi farmer explained:

The local variety of eggplant is called Gautan Gwari is usually smaller and slightly bitter – the improved one is called Na Gona. Most of us farmers and even the buyers seem to prefer the improved one because it is juicier and sweeter. The Igbos [mainly from southern/eastern Nigeria] prefer the sweet one but some people like those from Jos [Plateau State] prefer the bitter one.

Indigenous knowledge and practices are thus dynamically involved with science. Due to this dynamic, it has been argued that “new agricultural technologies, and now new generations of biotechnology, are thus not simply alternative technical solutions to technical farming problems. Rather, each carries implications for social and moral relations, and their appropriateness – who might value them – depends upon these issues” (Fairhead and Leach, 2005, pp. 88).

The multifunctionality of agriculture in the two communities is equally encapsulated in other jobs they engage in. They are mostly agriculture-related placing agriculture at the centre of life of the people of Karshi on which they rely for their livelihood but also for other socio-cultural and religious purposes. Other non-tradable benefits of agriculture to the people of Karshi include ensuring environmental sustainability (e.g. through the design and maintenance of irrigation systems); the maintenance of cultural heritage; providing a means of recreation (hunting) and ensuring the general viability of the rural community. As a result, *fadama* farming among rural people of Karshi and Baddeeggi farming communities surpasses economic reasons. Agriculture is more than just the basis of food security and subsistence. It makes significant contributions to other sectors of the rural economy and contributes in improving the quality of life of those who engage in it particularly women as is the case in Karshi and Baddeeggi.

4.17 The Institutional Framework for Sustainability in *Fadama* Areas

Data collected from respondents in Karshi and Baddeeggi point to the absence of or limited institutional framework that supports smallholder sustainable food production. First, the government believes that increasing production is only possible through sustained and increased provision of fertilizer, herbicide, insecticide and mechanization. This understanding was expressed by an agricultural specialist in this way:

...most crops grown in Nigeria are fertiliser dependent, for example maize is a fertiliser dependent crop. The other one that is fertiliser dependent is rice. These two crops are fertilizer dependent, but even more so rice. Less fertiliser dependent crops are sorghum, millet, and acha (Fonio). But even tubers, root crops, a lot of them require either manure or fertiliser. This is why we need to provide lots of fertilizer to our farmers and at the right time.

There is no indication of government's involvement in understanding and improving sustainable smallholder farming systems and practices such as mixed cropping. Instead, traditional farming systems are seen as the reason behind the low productivity of smallholders. A World Bank official expressed the aversion to smallholder traditional agriculture in this way:

We cannot continue with the hoe and cutlass culture and get the kind of production we want. We cannot continue on low tillage type agriculture, no fertilizer, no input, just planting on bare earth. We cannot continue on fallow system, farmers moving from one place to another... we are very lucky here we have the land. We are not maximising and we not getting optimal results from the land! We have to embrace these modern methods and make the most of them so that we can feed our people.

Government's solution is built around the principle of modernizing smallholders and providing them with the means to become commercial farmers. According a WB official,

The major problem we have with Nigerian agriculture is that we have dwelt more on extensification rather than intensification. We should get to the situation where we can expand the productivity of our crops and the only way to do that is to get a package of input support that can address the issues adequately.

Yet, even in this regard, the consensus among the smallholders in both Karshi and Baddeeggi is that support from the government by way of farm inputs supply is negligible or totally non-existent. This lack of support and incentive has eroded agriculture and is continuously pushing smallholders out of food production as this farmer explained:

A lot of us farmers have stopped rice and food production. Many of us prefer instead to go for sugarcane production simply because even if they produce rice there is no good market for it and you get so little after spending so much time, energy and money. So what is the point of somebody producing, using all his labour and input and at the same time getting nothing or a low return? It is the same reason why our children don't want to be involved in agriculture.

Generally, support for agriculture has dwindled in the last decade as is evident from the abysmally low budgetary allocation for agriculture and related activities.

Farmers find themselves totally lacking in areas of agricultural extension, credit schemes/loans, and general farm inputs. The government sees agriculture as a ‘peasant’ activity and hence invests less than 1% of Nigeria’s annual GDP back into agriculture. Funding for agriculture has not only been inadequate (as shown above), it has also largely been unstable as shown below (fig 15):

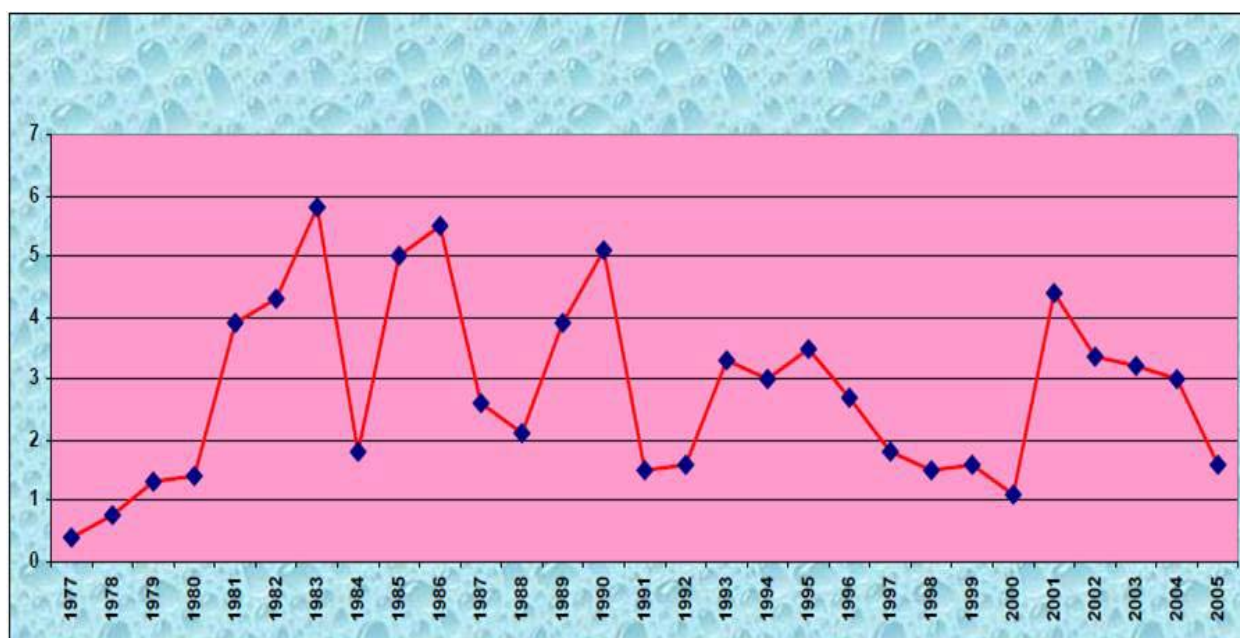


Figure 15: Agricultural share of Federal Government Budgets (%), 1977-2005
Source: African Institute for Applied Economics, 2005

The core of Nigeria’s agricultural policy has not changed for over three decades. The last comprehensive agricultural policy document in Nigeria was published in the 1980s with the aim of repositioning agriculture and saving it from the deterioration that the sector experienced in the period after independence (1970-1979). The government adopted a package of policy instruments to improve the performance of the agricultural sector. They ranged from macro policies aimed at stabilizing prices and farmers’ income, agricultural sector policies aimed at food self-sufficiency, and policies on support services aimed at improving agricultural extension and technology transfer. These policies have little changed since the 1980s and are ill prepared to respond to the food and agricultural impasse in Nigeria in the era of climate change¹³. Shaped by donor institutions (particularly the WB) and laced with pro-smallholder rhetoric, the bias was towards large-scale/‘modern’ farmers in Nigeria. The pervading understanding of agricultural development and the means to increased agricultural productivity in Nigeria remains predicated on increased use of external inputs. There is an absence of a coherent policy on agricultural sustainability that seeks to effectively draw from traditional agricultural practices.

¹³ Used throughout this thesis to refer to “the alteration of the earth’s climate caused by the atmospheric accumulation of *greenhouse gases*, such as carbon dioxide, as a result of human activity” (UNFPA, 2009, p. 4)

Rather than seek to harness the best of traditional agricultural practices and blend them with the best of contemporary scientific knowledge, smallholder farming is dismissed as being archaic and unproductive. Officials of the government, WB and certain members of the academia interviewed argue that the emphasis should first be on how to achieve food self-sufficiency. Consideration for sustainability is second to that. The elite reveal profound scepticism on the capability of smallholders to feed Nigeria unless they metamorphose into 'modern' farmers. Due to the neglect of smallholders, land is gradually becoming an out-of-fashion occupation as seen in the ages of those involved in smallholder farming (the mean age being 37). There are few direct policies targeting smallholders and where they exist, implementation is inept. For instance, support for small-scale farmers in form of credit schemes and farm input is virtually non-existent. However, this still compares well in relationship to the US and the UK. For instance, in the US, the average farmer age is 55 while it is 57 in the UK where half of the children of farmers are not interested in going into the industry leading to a decline in workforce skills in key areas (NFU/BBC, 2001).

The *Fadama* II Project, funded by the WB was meant to be a departure from past practices. The approach adopted in the project is community driven that allows farmers to take charge of their development priorities. Yet, even this approach is limited because farmers are required to co-fund whatever project they identify and prioritise. Most of these smallholders do not have the initial capital required by the WB for partnership and hence they are unable to participate. None of the farmers interviewed in Karshi/Baddeeggi villages has benefitted from any credit or input scheme of the government or the WB under the *Fadama* Project.

In addition to the lack of institutional support, smallholder farmers in Karshi and Baddeeggi continually see their habitat and ecosystem destroyed by the government as a consequence of construction projects (e.g. highways) through and across their communities because of their proximity to major cities (Abuja and Bida). Thus, their farms and source of livelihood are destroyed with little or no compensation. Some farmers get paid as little as N10, 000 (£50) /ha.

Besides the direct destruction of their farms and crops, other observed effects of massive construction projects in the area include erosion risks due to the constant movement of heavy machineries in the fragile *fadama* ecosystem and the digging that is often carried out in the process of such constructions. Also, a lot of the traditional tree species used by the community either for food, medicine or as a source of cooking wood are destroyed. The farmers are therefore compelled to find alternative means of livelihood where they cannot access other lands and this increases tension in the community and puts strain on available land.

4.18 Extension Bias, Productivity and Sustainability of *Fadama* Agriculture

Research and extension, both valuable means of improving smallholder farmers' productivity, are largely neglected in Nigeria. Quite the opposite, attention is paid more to large-scale farmers, a legacy of colonial and post-independent eras when the focus was on cash crops like cocoa, oil palm, rubber, groundnut and cotton. This bias is indicated in the fact that 72.3% of the respondents in Karshi have had no contact with extension providers. In fact, there were only two (2) extension workers stationed at Karshi, a community of over a thousand farmers. Lack of access to extension is therefore a major limitation as explained by an extension worker:

If there is effective extension, then the farmer knows where to grow which crop, when to grow which crop, the amount of fertiliser to be applied and other inputs. The farmers also get to learn better management techniques which help them to increase their yields. Where there is no extension, important information, knowledge and technology are often not passed to farmers.

Tracing the history of extension management in Nigeria, Udo (1990) identified two dominant approaches. The first is the bureaucratic system which placed extension services exclusively under the Ministry of Agriculture and other government parastatals. They were largely unsuccessful in stimulating productivity among smallholder farmers as seen in the apparent failures of food production programmes such as the National Accelerated Food Production Programme, the River Basin Development Authorities, Operation Feed the Nation, and the Nigerian Green Revolution.

The second dominant approach is the Training and Visit System (T&V) used by the Agricultural Development Programme and funded by the World Bank, especially in the 1980s. The principles of T&V as spelt out by Benor and Harrison (1977) and Benor and Baxtar (1984) include: well defined and structured hierarchy, a bi-weekly information dissemination visits to farmers/groups, regular training of village level workers by specialists, restriction of extension staff to strictly agricultural information services, regular workshops that bring together research station scientists, subject matter specialists and extension leaders and finally, emphasis on 'most important' crops. The T&V approach to extension has been relentlessly criticised for many reasons among which are: its heavy "focus on cereal yield increases, failure to address the diverse service needs of poor smallholders, rigid top-down approach, too high cost, lack of attention to economic and marketing aspects" (Ilevbaoje, 2004, p. 52).

In the case of Nigeria, the failure of the World Bank's sponsored T&V system can be attributed to its monotony, forced contact between farmers and extension workers, 'specialists' not attuned to on ground reality of smallholder farming, ineffectual training events due to lack of proper information dissemination, neglect of extension teaching (replaced with on-farm visits), lack of

contact between 'subject matter specialists and researchers'(Johnson, 2003). Despite the shortcomings of this system, the T&V approach remains in the mainstream of Nigerian extension management.

Whatever extension approach is adopted in Nigeria, it will have to deal with the specific problems of inadequately trained, badly paid and poorly motivated extension agents, frustrating working environment, absent or weak linkage between research and extension, inadequate information on and understanding of the features of smallholder farming systems, such as mixed cropping (Udo, 1990).The test is, therefore, to increase funding for research institutes and to modify research programmes to give smallholders priority. Research institutes can produce innovations aimed at increasing the productivity of smallholder farmers in a sustainable manner. They can help in the fabrication of simple implements to reduce the tedium of manual labour among smallholders, provision of locally improved varieties of crops, alternatives to inorganic fertilizer and general improved farm management techniques to minimize use of external inputs. Funding for research and extension services has dwindled over the years in Nigeria and has remained the exclusive domain of the government. Alternative funding for agricultural research and extension is almost non-existent and there is no evidence from this research that farmers are willing to pay for extension.

4.19 *Fadama* Farming, Gender and Power Relations in Karshi and Baddeggi

An examination of the *fadama* farming in Karshi immediately reveals the place and importance of women in the production chain. Inextricably linked to agriculture and to the role that women play in food production in Karshi are other complex issues such as religion, social process and power relations. Findings in Karshi reveal and corroborate what is now a widely accepted fact, namely that women are pivotal to development and food provision in Africa and many parts of the developing world.

In Karshi, a substantial quantity of the food consumed and sold is produced by women. For instance, rice is the exclusive reserve of women while the men are involved in the cultivation of crops such as yam, cassava, maize and sorghum. In addition to rice, however, other important crops grown by women in Karshi include cowpea, vegetables and fruits and beans. Much of Karshi's agricultural productivity relies on women's labour and the multiple roles they play in the general life of the community. Most of the women are in their most productive ages and invest most of their energy in the agricultural enterprise. Women's labour is thus the lifeline of Karshi's agriculture as they are involved in all stages of agricultural production: land preparation, planting, weeding, chemical application, harvesting, transporting, processing and marketing.Karshi

women are the string that holds together the social milieu and ensure stability through efficient juggling of their roles as farmers, mothers, marketers, cooks and health care providers. In addition to working on their own farms, they also help their spouses at various stages of the process of agricultural production. Additionally, women also feed and milk animals and raise poultry and other small animals. The labour of wives is similarly complemented by help from female children, co-wives and co-operatives (*gaiya*). Thus, on average, women spend more hours on the farm than men who claim to attend to other more 'masculine' functions. Generally, men make decisions while women do the real work.

In addition to their major role as food producers, Karshi women, like all rural women, have to meet the demands placed on them by religion and socio-cultural circumstances. Thus, they often have to return home at given hours to take care of domestic needs: cook for the family, take care of the children and wait on their husband. Many mothers take their infant children along to the farms and look after their needs between working hours. So, women often take breaks to breastfeed and clean their children up. Thus, competing tasks, especially during the farming season, drains women of energy and exposes them to many health risks. For example, after the exhaustion of farm work, women come home to cook with babies strapped to their backs while enduring the smoke from the firewood. Many women report suffering from backache, general fatigue (from bending down, working on the land, and pounding yam – all of which are labour intensive) and respiratory problems. Notwithstanding, they have to carry on because a break means more difficulties in the family.

In Karshi, the right of women to what they produce is well protected as the woman is fully entitled to what she produces and to the proceeds from sale of the same. She is under no compulsion to give or share with the husband her income. Most women, however, share in the responsibility of feeding their children and often take from their reserves in the event that the husband is unable to provide sufficiently for the family. This is important because many of the women are in polygamous relationships and, whereas it is the husband's traditional duty to provide food for the family and shoulder other social pressures, it is often the women who are left to carry the burden. For instance, the health care needs of the children are met by women from their income.

The men in Karshi are, for the most part, supportive of their wives and, in addition to showing goodwill, some of the men give their wives financial assistance and support them with some aspects of production such as applying chemicals on their farms. Similarly, the men ensure that their wives have access to as much land as they need and as is available. In general, the men are aware of the important role their wives play as mothers, wives and farmers. This recognition is

higher among men who do other jobs alongside farming and who often look up to their wives to supplement their income.

This increased participation of women in the agricultural labour force as independent producers, unremunerated family workers or as agricultural wage-workers has been referred to as the *feminization of agriculture*. The increasing role of women in agriculture is well documented as they constitute 70% of the world's agricultural workers and 80% of food stuff producers (FAO, 1985). This is even more so in developing countries where women make up more than two-thirds of the workforce in agricultural production. Africa has been described as the region for female agriculture per excellence (Bryson, 1982). In Nigeria, more than 80% of rural women are engaged in agricultural production and forestry and provide more than 70% of the labour force (Basalirwa et al., 2005; Soludo, 2008).

Notwithstanding their input to agricultural production, women are greatly disadvantaged and have no ownership over the means of production, land (Rahman et al., 2004). Findings from the fieldwork amply demonstrate that the disadvantageous position of women in traditional African communities is firstly a result of religious and cultural anachronism which understands the woman in a 'certain way' – often negative - and thus constructs her identity and role accordingly. For instance, in Karshi, women are culturally considered as subordinate to their male counterparts and in many ways their rights, such as access to land, is tied to marriage and hence to men. This not only gives the man precedence and power over the woman but also restricts efficient planning on the woman's part as the land can be taken away in the event of divorce or the death of the husband. The attitude towards women was captured by the chief of Orozo community in Karshi:

If she owns land just like the man, honestly there is a problem there. She won't respect her husband. Some women are like men. And if you allow a woman to have her own property, then she will hardly take care of the husband. Also it gives the man leverage over the woman in case of a fight, a disagreement or a quarrel. If the husband threatens to take his land back, the woman remembers the little benefits she is getting from the farm and then recants. Also, a woman cannot be relied upon to protect the land which is sacred to our people. She can decide to give up for money after all she might not be from this community

In general, three factors determine land tenure and women rights in Northern Nigeria: religion (*Shari'a*), local customs, and politics (Meek, 1949).

In Badeggi on the contrary, women's role in agriculture is limited because male respondents believe that Islam defines clear roles for men and women. The role of the man is to be a

breadwinner while that of the woman is caretaker of the home/children. Thus, secluded women are exempted from farming. Consequently, all the men interviewed in Baddeggi did not allow their wives to farm. Ironically, both Karshi and Baddeggi are predominantly Muslim. This shows a variation in interpretation of religious precepts. Significantly, however, the preponderance of women in agriculture in Karshi confirms a recent study in Northern Nigeria which shows an increase in the number of women involved in agriculture (Rahman and Alamu, 2003; Rahman et al., 2004).

The perpetuation of this system that oppresses women is deliberate as a means of control and ascendancy by the man. The realm of the sacred (religion), which is considered as sacrosanct and infallible, provides a subterfuge for this continued dominance. In an open admission, the chief of Karshi admitted that men use land ownership as leverage against women. This allows them to exercise power and control over the woman. Men often use threats of land withdrawal to reduce the risk of dissent and rebellion from their wives. According to the chief, “the women are as powerful as it were, because they earn good money from farms and in a way, the man cannot really tell her much, because she contributes in family sustenance. The land, therefore, is the only means of control that the husband has over the wife.” Thus, men defend and perpetuate the laws of land inheritance because it favours them (Gopal and Salim, 1998).

The response of women through ‘silence’ has only affirmed and consolidated traditional gender roles. Many women are reluctant to discuss the issue of land rights but when they do, they express dissatisfaction at the *status quo*. Whereas some accept the situation on the basis of religion and culture, a few others express a desire to see a change, even though they realize it is going to be difficult given the prevailing circumstances. The women respondents are aware of their contribution to the rural economy and family subsistence and are proud of having an independent source of income apart from their husbands. Similarly, they show consciousness of the power dynamics which men propagate in the name of culture and religion. However, none of the respondents feel they can change the existing order even if they all wish they had more access to land and credit.

In conclusion, if smallholders are generally maligned in government’s development policy, women suffer the double tragedy of government neglect and traditional oppressive structures. First, they are rarely targeted by agricultural programmes which are mostly male-centric and based on a limited understanding of the roles women play in agricultural production. Secondly, women are further restricted by religious and socio-cultural conditions which view them as subservient to men and second class citizens. Any attempt at empowering African women should first aim to critically

address cultural elements of ‘anachronism, authoritarianism and supernaturalism’ (Wiredu, 1980) that view women in a negative, subordinate way.

CHAPTER 5

CONSTRAINTS TO AGRICULTURAL PRODUCTIVITY AND SUSTAINABILITY IN KARSHI AND BADDEGGI

5.1 Introduction

An important category that emerged from the Grounded Theory analysis centres on constraints to sustainability and productivity. The constraints encountered in Karshi and Baddeggi range from institutional to biophysical and socio-economic. They were identified both by *fadama* users (study groups x and y above) and policy makers and government officials (study group z) (see figure 11). These constraints are discussed in greater depth below.

5.2 Irrigation and the Seasonality of Agriculture

Despite the inherent potential of *fadama* farming to be productive, the farmers are constrained by the seasonality of agriculture and the changes in rainfall patterns in the last few years, as a result of climate change. A farmer describes this constraint:

...I can tell changes in the weather. It is not just about the soil – the rains seriously affect yield. If the rains are poor, the yield will be poor even if the soil is good. In the last few years, rainfall has been unpredictable and sometimes irregular – but this season the yield has been poor even if the rains are good. The soil is weaker than it used to be.

Erratic rainfall means that planting is delayed and this in turn affects crop yields and the time for harvesting. Furthermore, seasonality means that many farmers can only produce during the rainy season (April-September) and do little for the remaining months of the year. Also, erratic rainfall generally leads to drought stress. This is a problem especially for *fadama* farmers that practice recession (dry season) farming as rainfall affects the level of water/moisture retained by the *fadama* lands. Thus, the complimentary relationship between *fadama* land and rainfall, which has been exploited by *fadama* farmers for centuries, is continuously endangered either by drought or by erratic rainfall (Shiwachi et al., 2008).

Closely related to the problem of agricultural seasonality in Nigeria is the difficulty in irrigation. Many of the farmers rely on simple and traditional means of irrigating their farms and this poses a problem for farms that are far from water sources or on sloppy areas, especially at times when the water level is low due to drought or poor rainfall. The use of simple pumps has gained popularity among the farmers in Karshi as this makes water pumping easier for them. Yet, not many of them

can afford to buy water pumps and the schemes put in place by the government and WB to assist farmers in purchasing water pumps is unrealistic as it places impractical demand on poor, low earning farmers who cannot provide the counterpart funding required.

Generally, the history of government's intervention in irrigation in Nigeria has been skewed towards large-scale systems that totally ignore the necessity of simple and adapted technologies based on existing cultural practices and suited for the purposes of smallholders. Thus, dams and major structures were constructed (some of which still remain to be completed) over a period of twenty years under parastatals such as the River Basin Development Authority (RBDA). With an investment of over \$3 billion in irrigation between 1970-1980, large-scale irrigation systems failed to achieve the needed increase in food production, reflecting the inability of the government to meet the targets set out in the national Development Plan of Nigeria (Adams, 1991).

Increasingly, however, the government and development agencies have started to invest in informal small-scale irrigation in light of low level or non-participation of smallholders in large-scale irrigation (Kolawole, 1982; Etuk and Abalu, 1992). Findings in both Karshi and Baddeeggi suggest widespread willingness to adopt small-scale motorised pumps, a finding replicated in research in nearby states such as Niger and Bauchi (Baba, 1993). Thus, there is need for more funding and research in the area of small-scale irrigations as this has the potential to boost agricultural production of smallholder farmers in rural parts of Nigeria.

5.3 Harvest/Post Harvest Losses

Harvesting, handling and storage are obvious constraints to food availability in Karshi and Baddeeggi. This reaffirms the point that the problem of food security in Nigeria is more than just that of production but more of inadequate management, sustainability and diversification of foods and their processed derivatives. It is generally estimated that over 40% of farm products are lost due to storage problems among smallholders in Nigeria (Bogoro, 1999). Agricultural production improvements in Nigeria are never matched with post-harvest storage policies, strategies and practices as market and technological interventions have been either grossly inadequate, misdirected or haphazardly made.

In both Karshi and Baddeeggi, a lot of food is lost due to inefficient processing and storage and also due to lack of processing implements. For instance, whereas the farmers are able to store grains such as maize and sorghum in barns, and tubers such as yam and cassava in dry rooms, storage of perishables like vegetables and fruits (tomatoes, eggplant, okra, lettuce, spinach, among others) poses a significant challenge. Some resort to slicing and drying but for the most part. What is not

sold in the market or consumed in the household is usually thrown away. A farmer in Karshi described how loss results from inefficient and insufficient processing techniques:

After cutting the rice, we usually trash it right there in the farm on shasha (trampoline). But if there is not enough room on the farm, we can do it at home. While the men do the trashing, the women usually winnow and make sure it is clean and free from chaff. Then it is packaged in bags and brought home. Then it is sun dried for a couple of days to completely remove any trace of moisture. However, we lose a lot during the process of thrashing, transporting and storage – but we do our best to make the most of it. We also lose a lot to insects and pests either on the farm or due to flaws in storage.

Furthermore, fire outbreaks are a common means of crop loss and this is so even in the barns which have thatch roofing. Other means of produce loss include biological losses to insects and pests, especially rodents.

Nigeria lacks adequate organized system of storage (silos) that can acquire the surplus of food produced by the farmers for storage. Farm produce handling in Nigeria remains primitive and undeveloped. Many crops abound at a given season and disappear as soon as that season is over. Poor infrastructure (road and transport systems), marketing facilities and high cost of transportation further compound the problem of wastage.

Poor food marketing and lack of production incentives add to the problem of food losses in Karshi and Badeggi. Farmers do not get favourable pricing for their produce neither do they get any incentives. Farmers are left to their own devices and no cushions are provided for them against periods of price fluctuations. Mode of disposal of farm produce is through market which accounted for 90% and the farm gate 10%. This is facilitated by the proximity of the village market which is open for business every four days. Karshi village is connected with motorable road to Abuja city which helps with easy evacuation of their produce. However, the road is in a deplorable state and the farmers hardly get fair prices for their produce from the buyers who come from all parts of the city (Abuja). The buyers re-sell these same farm produce for twice or thrice the amount they paid for them. In the end, the farmers are the losers as they have limited access to city markets.

There is the need to cut down on losses in harvest and storage through enhancement and application of indigenous techniques/technologies, fairer prices for farmers, improved infrastructure, improved quality of smallholder produce, private sector involvement and more government funding for research.

5.4 'Parasitic' Weeds

Parasitic plants, especially striga (*S. aspera*, *S. densiflora*, *S. gesnerioides* and *S. hermonthica*), pose a significant challenge to increased productivity among the farmers in Karshi and Baddeeggi. In fact, it has been described as the most pressing problem in the whole of the North-eastern and North central regions of Nigeria and indeed West Africa as a whole (Saueborn, 1991; Gworgwor et al., 2001). *Striga* is an obligate parasite and depends entirely on host plant for its nutrient requirement. *Striga* germination and growth is often in response to certain substances exuded by host roots (Cook et al., 1972). *Striga* (*S. hermonthica*), the most pervasive species in both Karshi and Baddeeggi, significantly reduces maize, rice and sorghum yields and leads to significant economic losses to the farmers. *Striga* infestation results in reduced plant height, panicle length, panicle weight and heavy infestation often kill plants before heading.

Quantifying crop loss to *Striga* is difficult but Ramaiah (1987) reports 10-35% loss while Doggett (1998) estimates 59% sorghum loss due to *Striga*. In general, an average loss of between 5-15% is estimated within the African region (Riches and Parker, 1995). Maize is generally very susceptible to *Striga* attack and as a result, yield loss is usually higher (Ogunbodede and Olakojo, 2001).

Biological and cultural methods of controlling *Striga* have been effective in some parts of the developing world and a careful study of these successes can greatly reduce economic loss due to *Striga* in the *fadama* areas. Such methods include hand pulling, crop rotation and trap cropping and germination stimulants. In Kenya, *Striga* has been controlled by intercropping with *Desmodium* spp. (Khan et al., 2002). Legumes have also been used to control *Striga* with an observable increase in yield (Khan et al., 2007). Mullen et al (2003) have proposed a bio-economic model for *Striga* control. It combines the implications of various agricultural practices for *Striga* infestation levels and the economic repercussions of *Striga* infestations levels and pre-determined cultural practices.

Promoting these biological methods of *Striga* control requires renewed and viable extension and an attitude change. However, research on *Striga* control in Nigeria is on-going but resistant varieties (inbred/hybrid) have been reported in various parts of Africa (Kim et al., 1984; Olakojo and Kogbe, 1999; Ogunbodede and Olakojo, 2001; Ezeaku and Gupta, 2004). However, a lot remains to be done in this area for effective control and hence the need for sustained search for sustainable resistant varieties.

5.5 Low Soil Fertility

Inherent low soil fertility constitutes another major challenge to smallholder food production in the *fadama* areas. By FAO's rating, most lands in Nigeria are between low to medium in fertility. An

extensive body of literature exists on the inherent problem of soil fertility in many parts of Northern Nigeria due to factors that range from biophysical (nutrient deficient parent material), chemical (nutrient depletion) and socioeconomic (inflation, poor producer price, poor infrastructure, and unfavourable exchange rates) (Balasubramanian et al., 1984; Bationo et al., 1996; Chude, 1998; Yusuf and Yusuf, 2008). In the case of *fadama* areas, the problem of soil fertility is compounded by salinity and sodicity development as a result of high ground water and constant irrigation which in turn pose hazards to soil and crop productivities (Mustapha, 2007).

In addition to the above factors, low soil fertility as a result of continuous cultivation (due to increasing population and city expansion) is a limiting factor to increased productivity among the farmers in Karshi and Baddegi as explained by this agriculture expert:

...the major reason why our people migrate to other parts of the country is because our soil has died, literally died. It is no more fertile. It has been oversubscribed. And this is very obvious and unless there is fertiliser or manure then the farmers cannot really produce much from the land?

Continuous cultivation exerts pressure on the soil leading to soil acidification and decline of exchangeable cations, and decrease of soil pH and calcium (Agbenin and Goladi, 1997). This explains the appeal of inorganic fertilizer to majority of the farmers as the quest for higher yields becomes more dependent on fertilizer as alternative methods (such as the use of organic fertilizers) are generally unsupported by policy makers. Some farmers are now venturing into unsustainable agricultural intensification given the decline in yield and unfavourable market conditions.

Overall, farmers report a decline in yield from lands that have been in use for over 5 years, especially where cereals such as maize and sorghum were planted. This is true despite fertilizer application. The problem of soil fertility is compounded by erratic rains – all of which affect the output of the *fadama* farmers. There is an appreciable decrease in vegetative cover in most of Northern Nigeria due to decline in rainfall which in turn exposes the soil to wind and water erosion (Hess et al., 1995; Nicholson et al., 2000). This is, in fact, a challenge to efficient food production in the whole of Northern Nigeria where there is strain on soil due to threat of desertification, nutrient mining and soil erosion. Yusuf and Yusuf (2008) have shown that there has been steady decline in cereals yield (maize, sorghum, millet and rice) in the area over the last decade (table 31).

Table 31: Yield trend and growth rates of cereals in Nigeria, 1996-2005

Years	Maize Actual (kg ha) (%)	Growth	Millet Actual (kg ha) (%)	Growth	Sorghum Actual (kg ha) (%)	Growth	Rice Actual (kg ha) (%)	Growth
1996	1326		1061		1144		1750	
1997	1251	-5.67	1076	1.41	1107	-3.22	1596	-8.82
1998	1320	5.52	1000	-7.03	1133	2.29	1602	0.41
1999	1381	4.63	1064	6.37	1126	-0.59	1496	-6.65
2000	1027	-25.64	1050	-1.28	1120	-0.54	1500	0.27
2001	1143	11.32	944	-10.05	1021	-8.81	1247	-16.86
2002	1044	-8.68	990	4.81	1090	6.72	1010	-18.99
2003	1070	-2.49	1030	4.04	1135	4.13	956	-5.45
2004	1070	0.00	1030	0.00	1140	0.88	960	0.00
Mean	1195	-2.29	1027	-0.25	1109	0.00	1395	-8.01

Source: (Yusuf and Yusuf, 2008, p. 16)

In the past, banana farmers in Karshi practiced the fallow system or the cultivation of virgin forests and hence could afford to switch farms once every 5-6 years. This practice is no longer practicable due to population expansion and lack of readily available virgin land (Van Rueler and Prins, 1993). Hence, there has been a transition from shifting cultivation to a system where the same plot is continuously cultivated. Different crops are planted and alternated between seasons to protect soil integrity and ensure fertility over long periods of time.

Due to the high cost of chemical fertilizer, the farmers have resorted to methods such as rotation/intercropping and the use of green manures to deal with the problem of soil fertility. Clearly, however, there is need for much research on how to sustainably increase soil fertility, especially because of the challenge posed by soil degradation which seems to continue despite several measures and approaches aimed at dealing with the problem (Sanchez and Leakey, 1997). Integrated soil fertility management has been suggested as a means to carefully incorporate “a wide range of adoptable soil management principles, practices and options productive and sustainable agro-ecosystems” (Yusuf and Yusuf, 2008, p. 21). This can only be achieved, however, with favourable socio-economic and political conditions.

Related to the problems of low soil fertility is imbalance in fertilizer use. Farmers often have no access to enough quantities of fertilizer and simply use whatever amount they can get. They are usually oblivious to any considerations as to what type of nutrients a given plant needs and at what stage it needs them. Sometimes this problem is the direct fallout of late supply of fertilizer by the government and many farmers only get fertilizer late into the farming season when many of the crops are already at advanced stages of maturity. In addition to this, inefficient land preparation and lack of timely control of weed - which can lead to stronger weed competition and reduced yield - are some constraints to efficient food production in Karshi and Baddeggi. Similarly, the

extension workers pointed out the problem of poor management such as low plant population, which affects crop yields.

5.6 Labour

Labour is a prominent limiting factor to many of the smallholder farmers in Karshi and Baddeggi as the whole agricultural process from land preparation, weeding to harvesting is done manually because most of the families (77%) rely on family labour, self-help organizations and farmer cooperatives (*gandu* or *gaiya*). A farmer in Karshi explained this concept:

The practice of gandu (community labour) is part of our culture and farming tradition. We as farmers come together and take turns to help each other. We start from one farm and move round through each farmer's land. We help each other either during land preparation, weeding or harvesting. The farmer whose farm we are working on usually provides us with food and drinks. Gandu makes the work easier for us.

Similarly, the majority of the farmers can neither hire labour nor buy labour-saving technologies (where such are available). In fact, the 23% that employ external labour restrict the number of people employed to between 2 to 5 and only occasionally throughout the farming season. Access to animal traction is similarly low among the farmers in the area of study which could help increase labour productivity and reduce the drudgery associated with smallholder farming.

As mentioned earlier, usually family labour seems ideal for the purposes of many smallholder farmers. However, there is shortage of labour during peak farming periods and farmers struggle to cope. One of the farmers explained their frustration in this regard:

We are not asking for much. We just need some help like simple hand-operated tractors or plows for animal traction to help us with land preparation. Most of the land preparation is done manually which is time consuming. We cannot produce more because we cannot expand even if we wanted to because labour is a major limiting factor. Those that can afford to usually contribute money to hire a tractor but the majority of the people cannot do that.

This problem is further compounded by the fact that many farmers send their children to school. The majority of those interviewed in both Karshi and Baddeggi value the education of their children saying they do not wish the same future as theirs to their children as this Baddeggi farmer explained:

All our children go to school. That you see the kids at home now it is because this is the fasting period (Ramadan). We are actually agitating for a primary school here. We have solicited help from the government. We don't want our children to suffer the way we have suffered and that is

why we are educating our children. Some of our children from this village go up to university or polytechnic and many of them don't want to be farmers like their parents.

It has been observed that Nigerian farmers wish for their children to be anything but farmers (Odigboh, 1976).

On the whole, more male children are sent to school and this means fewer hands to work the land except on weekends and school holidays. Thus, female labour constitutes the bulk of the family labour and extends from land preparation to harvesting. The shortage of labour, therefore, means delayed weeding or harvesting and this in turn means reduced yield. It has been estimated that up to 50% of the total crop yield in Africa is lost due to late planting (Steiner and Kienzle, 2004). The tedium involved in soil tillage has led many farmers to either adopt low or no tillage (in addition to other methods such as crop rotation/intercropping, use of cover crops and green manure) as means to both controlling weed and cutting cost associated with the use of herbicides. However, for other crops such as yam and cassava, tillage is almost inescapable in these areas.

In order to reduce the demands of labour in smallholder food production, research is needed in the area of expanding cultural practices such as the ones already described and investment is needed in the area of small-scale, sustainable time and energy saving agricultural tools such as simple cultivators for weeding, planters, shellers, rice processing machines and mills and processing/storage tools for perishables.

5.7 Land Tenure/ Cultural Anachronism and Women Disempowerment

Many *fadama* farmers cultivate inherited lands which are often fragmented and shared among male children of a given household who can either give part or all of it to their wives, friends or rent it out. In general, land ownership in both Karshi and Baddeggi is communal and the land holding group is, in most cases, the family, under the supervision of the community (represented by the village head).

Culturally, women are not allowed land ownership in both communities. Ironically, in Karshi, the majority of the farmers (especially of rice) are women. A woman is allowed to either cultivate her husband's land (if she was married into the Karshi community from another), or her father's (if she is from Karshi) or both as the specific case allows. This means that women have no sole ownership over the lands they cultivate and ownership rights can be withdrawn by the husband or the father at any time (in the event of divorce or other related problems). A member of the chief's council explained this practice:

Let's say you have five children. You are the father; three males and two females. And you have farmland. Tomorrow, these two female children might get married to someone in Kano [state]. Automatically, she relocates to Kano. Now, what happens to the land here? This is why we don't give women permanent ownership of land even during asset/inheritance sharing. But if a woman says she wants to cultivate a portion of her father's land, she will be given the right to do so.

The reasoning behind this practice is, as explained by the village chief, that women are often married into other communities other than their parents' and this means they are considered 'strangers' having no ownership rights over land. Whereas this reasoning might not make sense to the outsider, land is often considered a traditional heritage and men as the custodians of this sacred inheritance. On the other hand, women's place in the village is not guaranteed because of factors such as marriage.

The implication of this cultural practice is that long term planning is not possible for many women as whatever their plans for the land is has to be in line with the targets set out by the man (husband or father). The woman is not guaranteed use in the successive season(s). Similarly, women have no access to choice lands and they make use of whatever is given to them. Often, the men choose the best lands for themselves and give the lands with low fertility to the women. This increases demands made by production on women.

The problem of land ownership rights is similarly faced by 'outsiders' as it is difficult to get land for agricultural purposes outside one's own indigenous community. Fluidity in land ownership is therefore a significant challenge as most farmers and intending farmers are restricted to particular areas and their potentials for expansion into more fertile areas are severely curtailed. For anyone to lay claim to land in these communities (and very much in any part of Northern Nigeria), the consent of the village heads is an imperative and not always easily forthcoming.

Thus, there is a dual and often parallel tenure system in Nigeria. The first being the traditional/customary tenure system already described and the second being the state tenure system. The result of this pluralism is ambiguity and insecurity in land rights, conflicts and disenfranchisement of vulnerable groups (women and migrants) (Abdullahi and Hamza, 2003; Cotula et al., 2004).

The Land Use Decree of 1978 unified Nigeria's land tenure system and vested all land on the state (mainly for agricultural and industrial development). This represented an attempt by the government to democratize landholding system so as to protect the rights of all citizens to access

and use land as against the customary land tenure system which made land the exclusive property of 'landlords' and families that controlled them. Land ownership, under the decree required a certificate of occupancy from the government and the payment of rent. The 1978 Land Use Act aimed at giving individuals access to land.

However, the customary tenure system has persisted, creating a gap between the legal provisions of the Decree and the real practice of land acquisition and use. In much of Northern Nigeria (Karshi and Baddegi for instance), land ownership remains communal as individuals have usufructuary rights to land in one's lineage/community area, which is passed on to one's heirs but cannot be sold or mortgaged. Existing cultural practices and land tenure constitute the major obstacles to the productivity of women farmers whose rights are fragile and transient and determined by factors such as marital status, number of children, and their sexual conduct. There were cases in Karshi where a woman's access to land was revoked by the husband because she had denied him what he considered to be his conjugal rights. A farmer in Karshi explained this further:

Sometimes what the men do is hard to understand – because they know that we don't own the land, they use it against us. If you refuse to yield to their demands or you want to be on your own [independent], they threaten to withdraw the land. Sometimes, let's say a woman refuses to sleep with her husband because she is tired or not feeling well, the men get angry and some get into a fight and others cease the land from the wife. It is very bad our situation.

Many women in Karshi expressed awareness of and sometimes anger at the tenure system. Similarly, they expressed dissatisfaction that their land rights are tied to their husbands or fathers. However, they did not express willingness to challenge the system.

In summary, the traditional tenure system in Karshi and Baddegi constitutes a formidable obstacle to women, non-indigenous people in these communities and any farmer desirous of increasing his/her farm size. This constraint is not limited to Karshi as the literature is replete with examples of how the traditional tenure system restricts and limits agricultural productivity and why the Land Use Decree of 1978 has been so difficult to actualize (Oluwasanmi, 1966; Adegboye, 1967; Ijaodola, 1970; Adeniyi, 1972; Famoriyo, 1972; Famoriyo, 1973a; Famoriyo, 1973b; Fabiyi, 1974; Wells, 1974; Olatunbosun, 1975; Osuntogun, 1976; Williams, 1978; Famoriyo, 1979).

Another issue related with the tenure system especially in Karshi is the issue of compensation for land taken by the government for development/industrial purposes. The Land Use Decree makes provision for compensation in such cases but this remains largely inefficient in Karshi as farmers

whose farms have been taken away by the government either receive nothing or negligible compensation. Additionally, the compensation to farmers is seldom prompt or adequate.

5.8 Socio-economic Constraints (Shortage of Funds/Capital)

Despite the fact that the bulk of the farmers derive their income from farming and farming- related activities, agriculture, specifically smallholder farming, has largely been neglected by the government. All of the respondents encounter the problem of funding and declare that they have not received any kind of financial support from the government or donor agencies for the purchase of farm implements, processing machines, or general farm expansion. Most of the farm implements used by the farmers (hoes, cutlasses, and machetes) are fashioned out either on the farm or purchased somewhere else in the village. All the respondents owned hoes, cutlasses and other farming implements. A few (12%) own water pumps and on one farm, there was a rice processing machine (provided by the land owner). In general, investment in capital goods in the study areas is low; so is investment by government in infrastructure. It is to the credit of these smallholder farmers that they have developed a self-contained economy where the system is dependent on itself, an element lost in mainstream agriculture. However, adequate research and funding can help to improve farm design and methods of production as well as modify and improve farm tools. Faced with limited income and lack of financial assistance from the government, the farmers say that they can neither improve nor expand their production base. Equally, they cannot diversify because they are limited by lack of funds and limited access to the inputs they feel they need. This farmer summarized the frustration faced by the farmers in Karshi:

No one has ever helped me with money or even a bag of fertilizer (you can ask the extension workers here)... I am not lying about this. Looking for help is often a waste of time. But in the past (when we were under Plateau state), I could get as many as 40 bags of fertilizer just for exhibiting my farm products at the annual agricultural show. These days the government has lost interest in us. The agricultural show is now weak and there is no encouragement [incentive]. So, now farming has been abandoned. Well, may be in the future this might all change. Even agricultural workers are not seen nor treated in a good way, how about us farmers? Farming has lost its dignity in the eyes of the government.

What meagre income they make from farming is expended on meeting food needs and other social pressures such as paying school fees and medical bills.

Poor returns for their products and low market rates were also major constraints to the farmers as this Baddeggi farmer explained:

There should be a good market for this paddy rice... At the end of the day, the farmers are left with the rice, and middle men come and buy them and take them to Kano or Lagos, mill them and make them into good rice that is being sold in the market at very high prices. So...for our farmers to be really happy with the yield and get the encouragement to produce more, there must be a good market and good return for what they produce.

Additionally, all of the respondents encounter a problem of shortage or lack of fertilizer (organic and inorganic). Inorganic fertilizer remains available but only through unofficial means and at prohibitively high prices. Yet, many of the farmers invest whatever little income they have on fertilizers because of the entrenched view that the success of crops depends on them. In most cases, official supply of fertilizer scarcely gets to the smallholder farmer and when it does, the timing is problematic (often way into the farming season). Also, there is a problem of information accessibility as most of the respondents interviewed expressed inability at accessing official channels for obtaining affordable farm inputs especially improved seeds. In general, however, as fertilizer becomes increasingly inaccessible to poor farmers due to high prices and government's erratic and inefficient policy on fertilizer and fertilizer distribution, they are falling back on organic fertilizer.

5.9 Recommendations: Strengthening the Sustainability of *Fadama* Agriculture from the Ground-Up

The solutions to Africa's agricultural impasse proffered by the technical and production function model (bigger dams for irrigation, higher inputs and more mechanization) have, to this point, failed to bring about the much needed increase in agricultural output of smallholder farmers. Yet, in many policy circles in Nigeria, this input supply model is still being identified as the best means of ensuring food security:

The problem of agriculture is lack of mechanized farming system. Right now, people are not interested in using hoes and cutlasses. It is an old way of farming practiced by our old parents, who have now grown old without the energy to continue to till the ground with these crude implements. The young farmers do not want to go into using crude implements, so what we need now...is the mechanization of agriculture...In essence, farmers need farm inputs such as tractors, insecticides and herbicides to improve and boost production... (Alhaji Aliyu Ahmed Aliyu Garafini, special adviser to the governor of Niger State on local government affairs) (Ojo, 2008b)

Yet, the acute failure of this model is reflected in the incessant food crises in many parts of the developing world and an increase in the number of farmers falling back on traditional methods as

seen in Karshi and Baddeggi. We need to rethink this model in light of growing evidence that traditional methods of production can be equally productive if carefully managed and promoted. The interest in sustainable alternatives is based on the fact that Africa's prospect of agricultural development based on continued energy consumptions is severely limited. Also, it is one of the regions worst hit by the effects of climate change (IAASTD, 2005).

Conversely, it is counterproductive to insist that the technical model be discarded without suggesting a compensatory alternative or replacement. Agroecology, a multidisciplinary approach in the study of agroecosystems, enables us to confront the problems of conventional agriculture and agricultural productivity in a holistic rather than the fragmented way in which these issues have often been treated. A look at the constraints to increased agricultural productivity among the farmers in Karshi and Baddeggi reveals the multiple factors involved (ecological, cultural, historical and socio-economic). Addressing one dimension of the problem does not necessarily solve the whole problem as seen in the apparent failure of a model strictly based on technical/technological intervention. What is needed is a multidimensional approach that sees the interconnectedness between productivity, sustainability, stability and equitability and hence the need for integral solutions.

In order to increase the sustainability of *fadama* agriculture, practitioners and policy makers can draw from the rich repertoire of traditional *fadama* knowledge. The challenge is to recover, enhance and entrench those traditional practices that enhance and maintain biodiversity and ecological balance. Significantly, however, any attempt at reviving and sustaining the interest of farmers in the use of traditional farming methods has to start by dealing with the twin problem of education and institutional support. Firstly, there is the necessity to re-orientate/re-educate the farmers who have become dependent on external inputs on the harmful effects associated with excessive use of chemicals and machines but more importantly, on the ability of traditional methods to measure and even surpass whatever gains they derive from use of external inputs. This requires humility in dialogue and an acceptance of the inadequacies of 'modern' methods that were initially forced on them and an acknowledgement of the efficiency of neglected traditional systems. This is crucial because, over the decades, the farmers have been made to develop a negative attitude towards their own farming systems and many farmers still doubt the efficacy of organic fertilizer and consider its use as backward, cumbersome and dirty. Correspondingly, the government has to, in addition to providing technical support, take interest in the activities of these small farmers, invest in research in that area and ensure that farmers get fair returns on their goods through better access to market and other infrastructure.

The strength of traditional systems is that they encourage soil fertility, regulates pest and increase the productivity by relying on the synergies that exist in the agroecosystem. Restoring *fadama* sustainability requires promoting sustainable traditional methods of soil fertility management and progressive chemical withdrawal. The farmers' dependence on inorganic fertilizer needs to be discouraged while sustained effort should be targeted at improving traditional methods such as increased use of organic fertilizers to replenish soil nutrients and reduce threat to underground water posed by chemical fertilizer. Organic fertilizers have great potentials especially for the purposes of poor smallholders because they are cheap and accessible and also because they have the potential to improve: the physical properties of the soil (Swarup, 1987), the biological diversity of the soil (Chai et al., 1988) and soil fertility and yield (Lal and Mathur, 1989).

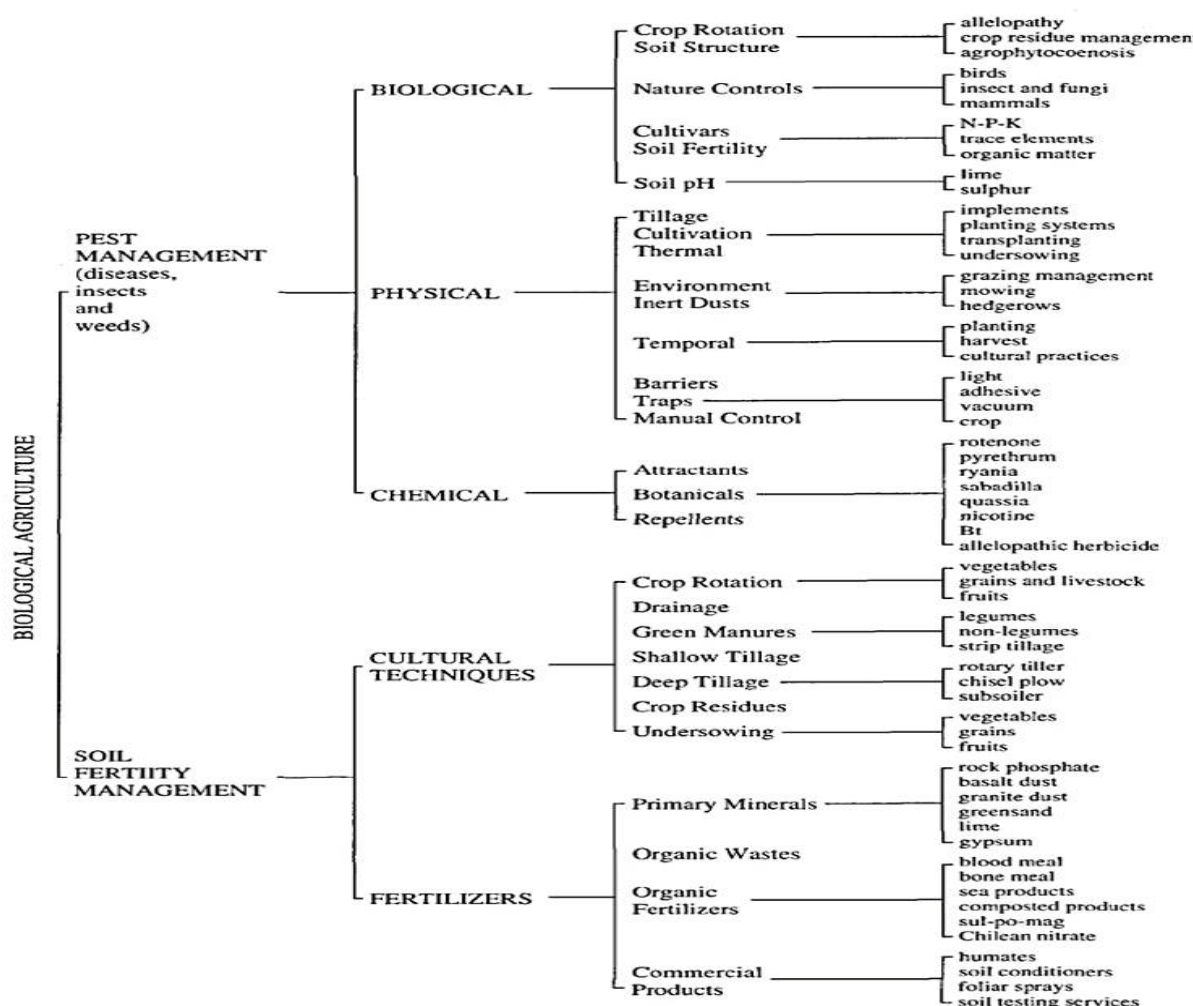


Figure 16: Schematic outline of available alternative agricultural practices
Source: (Altieri and Rosset, 1996)

The use of crop/animal by-products and animal manure (cow dung, poultry droppings) already common in Karshi and Baddegi needs to be encouraged as a means of ensuring soil integrity, cutting cost, and as a nutrient saving technique. Refuse composting, also common among smallholders, provides a cost-effective and cheaper alternative to chemical fertilizer. Recently, some efforts have been made at producing organic fertilizer in commercial quantity in some parts of Nigeria (Alimi et al., 2006). Such initiatives need to be encouraged as a means to increasing agricultural output. However, considering the size of smallholder farms, traditional methods of making and collecting organic fertilizer (e.g. composting) need to be developed and encouraged. In addition to the types of organic fertilizer already in place, the farmers can be encouraged to diversify and incorporate use of organic waste and fish/bone meal. The latter is important as many of the farms integrate crops and livestock and crop and fish. In general, more research and investment is needed in this area and other areas such as commercial humates and soil conditioners.

Cultural practices already in place that help in soil fertility management, such as crop rotation (using legumes), integrated farming (crops/livestock, crops/non-ruminants and crops/fish), the use of green manures/cover crops (e.g. beans), the use of crop residues (e.g. melon) and low tillage, also need to be encouraged and improved. These practices can be complemented with more research on other cultural techniques such as strip tillage (to create seed beds), deep tillage using rotary tillers, chisel ploughs and sub-soilers. These simple and sustainable methods can greatly reduce drudgery and provide economical and handy means of tillage. Additionally, the use of under-sown green manure as alternative to long term green manuring can be studied and experimented with as a means of increasing crop yields.

Despite the immense potential of integrated agriculture to fight hunger and reduce poverty (as evident in Karshi), government has not paid attention to this area. For instance, indigenous poultry resources remain neglected despite the less cumbersome feed requirements. Similarly, investment in small animals is ignored notwithstanding their high survival rates (as a result of the diversity in their gene pools). The “ruminant advantage”¹⁴ of small ruminants should therefore be explored in order to fit that into the socio-economic circumstance of smallholder farmers (Terrill, 1982; Timon and Hanrahan, 1986).

The prevalence of herbicide use among the farmers in both Karshi and Baddegi (a practice not unrelated to the pervasiveness of *Striga* in some *fadama* areas) poses a significant challenge in

¹⁴ Small ruminants are efficient by virtue of their biology (short gestation period and rapid growth). Also, they are efficient in producing food and fibre at low cost and better quality meat. Small ruminants are cost effective requiring little capita, they utilize feed materials that hitherto go to waste, can thrive on marginal lands, they complement each other (e.g. sheep and goats)

effecting a transition to sustainable agriculture. Cultural weed control methods such as crop rotation, well timed planting schedule, mechanical methods and others already discussed should be promoted. However, these practices need to be complemented by research into *Striga* resistant varieties. Some work has been going on in this area at the Institute for Agricultural Research, Samaru, a process that involves the screening of seed germplasm for resistance to *Striga* (Marley et al., 2004). Additionally, cultural strategies can only be effective if certain basic factors are better studied and understood, for example, weed/crop interaction. More research can also be done in other areas such as the use of crops that suppress weed germination, crop management methods (choice of variety, seed rate, crop spacing and establishment), bioherbicides, mulches for weed control, thermal control and solarisation.

Furthermore, physical methods (crop rotation, natural control) and biological methods (tillage, thermal, cultivation, environmental and temporal) of pest control (such as in IPM) should be encouraged as against the use of chemicals. Generally, these methods are more sustainable and cost efficient. Integrated pest management (IPM) is widely used and accepted as an effective and sustainable means of pest control. A study carried out by the International Institute of Tropical Agriculture (IITA) and the University of Belgium has recently found that certain nematodes, commonly parasitic and destructive to crops, could be used to naturally control pests in Sub Saharan Africa (SSA) (Osagie, 2008). Such research should be encouraged to help increase smallholders' income by reducing the cost of pesticides in regions already burdened with high transport, input and marketing costs.

In the area of water management, the challenge is to first enhance the productivity of rain-fed agriculture and, secondly, develop traditional small-scale methods and reduce their inefficiencies (e.g. water loss and labour involved) with a view to making them more accessible and sustainable. This is necessary due to the failure of large-scale irrigation schemes of the past which had adverse effects on *fadama* areas. Government's treatment of small-scale traditional irrigation methods and other simple methods has been cavalier, as it has favoured the introduction of technology regardless of compatibility. Smallholder contribution in rural irrigation projects is vital and this should be matched with sustainable farm management practices.

Furthermore, to boost productivity, all-season agriculture (such as recession farming among *fadama* farmers) should be promoted in a sustained and organized manner. This is especially a challenge in the drier parts of Northern Nigeria where many farmers are almost completely idle during the dry season even where there is potential for dry season agriculture. Special schemes and pilot

programmes should thus be designed to facilitate all-season farming and convert idle farmers and otherwise wasted labour to productive purpose.

Table 32: Classification of cultural practices potentially applicable in an integrated weed management system, based on their prevailing effect

Source: Weed management for developing countries, (Bàrberi, 2003)

Cultural practice	Category	Prevailing effect	Example
Crop rotation	Preventive method	Reduction of weed emergence	Alternation between winter and spring-summer crops
Cover crops (used as green manures or dead mulches)	Preventive method	Reduction of weed emergence	Cover crop grown in-between two cash crops
Primary tillage	Preventive method	Reduction of weed emergence	Deep ploughing, alternation between ploughing and reduced tillage
Seed bed preparation	Preventive method	Reduction of weed emergence	False (stale)-seed bed technique
Soil solarization	Preventive method	Reduction of weed emergence	Use of black or transparent films (in glasshouse or field)
Irrigation and drainage system	Preventive method	Reduction of weed emergence	Irrigation placement (micro/trickle-irrigation), clearance of vegetation growing along ditches
Crop residue management	Preventive method	Reduction of weed emergence	Stubble cultivation
Sowing/planting time and crop spatial arrangement	Cultural method	Improvement of crop competitive ability	Use of transplants, higher seeding rate, lower inter-row distance, anticipation or delay of sowing/transplant date
Crop genotype choice	Cultural method	Improvement of crop competitive ability	Use of varieties characterised by quick emergence, high growth and soil cover rates in early stages
Cover crops (used as living mulches)	Cultural method	Improvement of crop (canopy) competitive ability	Legume cover crop sown in the inter-row of a row crop
Intercropping	Cultural method	Reduction of weed emergence, improvement of crop competitive ability	Intercropped cash crops
Fertilization	Cultural method	Reduction of weed emergence, improvement of crop competitive ability	Use of slow nutrient-releasing organic fertilizers and amendments, fertilizer placement, anticipation or delay of pre-sowing or top-dressing N fertilization
Cultivation	Curative method	Killing of existing vegetation, reduction of weed emergence	Post-emergence harrowing or hoeing, ridging
Herbicide application	Curative method	Killing of existing vegetation, reduction of weed emergence	Pre- or post-emergence spraying
Thermal weed control	Curative method	Killing of existing vegetation, reduction of weed emergence	Pre-emergence or localized post-emergence flame-weeding
Biological weed control	Curative method	Killing of existing vegetation, reduction of weed emergence	Use of (weed) species-specific pathogens or pests

Closely related to the question of all season farming is the challenge of irrigation. Musa (1993) identified five enduring irrigation priorities for Nigeria which include: appropriate irrigation technology; capital; improving existing irrigation systems by considering more dynamic, cost effective and sustainable approaches to irrigation management, developing and/or expanding irrigation systems with input from the end-users/beneficiaries (emphasis should not be just on technology but also on socio-cultural attitudes and values of the people) and finally, irrigation development should be done with environmental considerations such as effects of flooding, water logging, depositing of salt and risk of vector diseases. However, agricultural productivity will be increased not just with increase in the quantity of water provided but in providing water in sufficient quantities and the right time (Movik et al., 2005).

Input substitution is a basic tenet of agroecology which stresses the use of alternative, low-energy input technologies. There is little doubt that technology is important in increasing agricultural productivity and, in the cases of Karshi and Baddegi, lack of labour-saving technologies is one of the major constraints to agricultural efficiency. However, technical innovation alone cannot provide a solution to the problem of food production as already demonstrated. What is needed, therefore, is a holistic approach in which the technologies invested in and introduced to the farmers are appropriate for the purposes of the farmers. For instance, simple irrigation technologies such as bucket and drip kit, treadle pumps, collector well technology and sprinkler irrigation can go a long way in serving the irrigation purposes of smallholders.

Furthermore, a realistic food security programme in Nigeria must take the problem of storage seriously as a means to saving the excesses from successive crop surpluses which can be used in times of natural and/or socially-driven catastrophes like acute drought, flooding, war, inter-community and intra-community classes, among others. Specific activities and interventions in this regard include building and utilizing existing strategic grains reserve. More importantly, appropriate family level, medium and large scale post-harvest and processing strategies must be evolved, defined and adopted to suit the peculiarities of Nigeria's level of technology as well as the socio-economic circumstances of smallholder farmers. A major problem over the years has been the inability of government to responsibly document many of the existing traditional practices in this regard which could simply be improved upon (Bogoro, 1999).

Investment in infrastructure (roads, schools, health care centres among others) is another imperative if the productive base of smallholders is to be expanded and improved upon. Infrastructure development should, nevertheless, take into consideration the socio-political dimensions of rural livelihood. Both Karshi and Baddegi are connected to major cities by roads,

often in decrepit conditions. However, the inner villages remain cut from cities and market centres. Linking them up with a good road network will ease movement of food crops from villages to the urban centres thereby reducing loss and wastage as well as increasing the income of farmers. As villages get connected to urban centres, however, the rights of smallholders to fair prices for their produce needs to be promoted as the present system exploits farmers who get meagre incomes for their farm produce. Agricultural markets need to be seen within their socio-cultural and historical contexts so as to limit the influence of the rich and powerful (Amanor, 2005). In general, the presence of relevant infrastructure like good roads, electricity and other important support facilities will provide the needed impetus to government programmes and initiatives.

From the foregoing, the most important factor that should underlie any attempt at improving the productivity of smallholder farmers in Nigeria and indeed the whole of Africa is institutional support (government and non-governmental sectors of the economy). Most governments in the West African region allocate barely 10% of their annual budgets to agriculture despite the fact that it provides employment to more than 80% of the population (Bi-Allah, 2008). Similarly, the attitude towards research must change and funding for agricultural research institutes¹⁵ should increase (Adedipe, 2007). Better funding and monitoring is needed for research and extension geared at developing existing knowledge/methods and technologies and generating more appropriate and adaptable ones. Agricultural research needs to be bold and innovative, looking beyond conventional wisdom and targeting the smallholder majority (Jones, 2005).

¹⁵In all, there are twenty one National Research Institutes in Nigeria: Arable Crops Research Institutes, National Agricultural Extension Research and Liaison Services (AERLS), Institute for Agricultural Research (IAR), Institute of Agricultural Research and Training (IAR&T), National Cereals Research Institute (NCRI), Lake Chad Research Institute (LCRI), National Root Crops Research Institute (NRCRI), National Stored Products Research Institute (NSPRI), Forestry, Horticulture and Tree Crops Research Institutes, Forestry Research Institute of Nigeria, National Horticulture Research Institute (NIHORT), Cocoa Research Institute of Nigeria (CRIN), Nigerian Institute for Oil Palm Research (NIFOR), Rubber Research Institute of Nigeria (RRIN), Animal Production, Fisheries and Oceanography Research Institutes, National Animal Production Research Institute (NAPRI), National Institute for Freshwater Fisheries Research (NIFFR), Nigerian Institute for Oceanography and Marine Research, Animal Health Research Institutes, National Veterinary Research Institute (NVRI) and Nigerian Institute for Trypanosomiasis Research (NITR). There is also one international research agency, the International Institute of Tropical Agriculture, (IITA). Most of these institutes are grossly underfunded and hence underperforming.

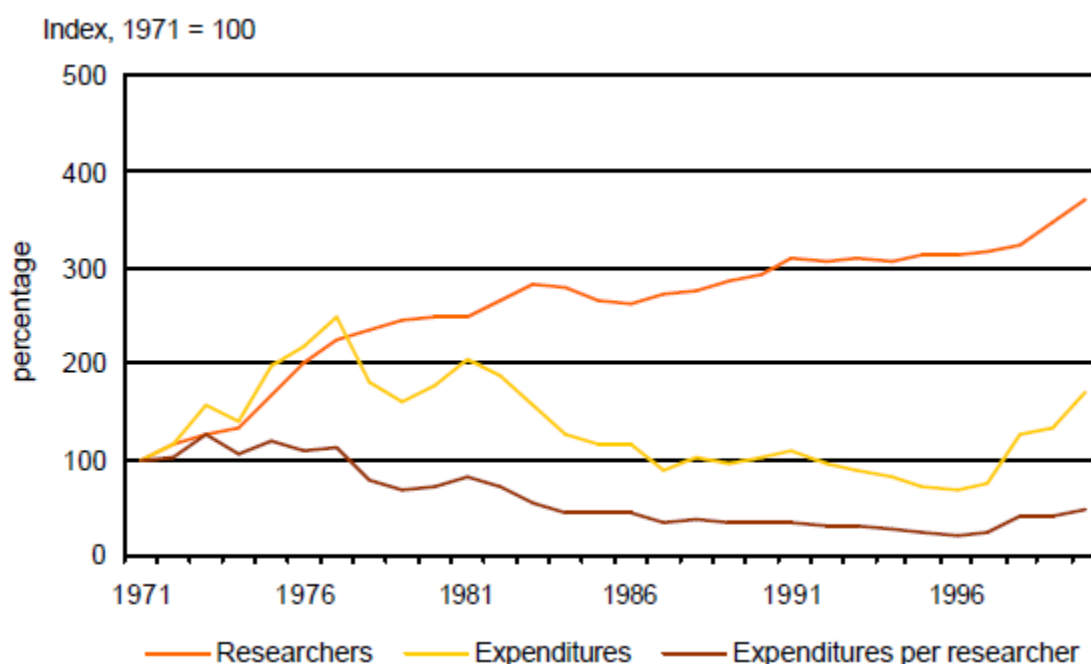


Figure 17: Public agricultural R&D trends, 1971-2000
Source: (Beintema and Ayoola, 2004)

With regards agricultural extension, a successful model should involve working with farmers *in situ* so as to understand their needs and build mutual respect. Such a model should also be integral relating human, technical and spiritual needs of farmers. Emphasis should also be placed on the local people as the key resources who should be encouraged trained, and assisted to organize themselves for their own development. Such a model should see extension officers as servants and facilitators not managers usurping farmers' management responsibilities. Consequently, local farmers should be engaged at every stage of planning and execution of policies, programmes and practices. It is also crucial to promote extension that entails sharing with other regions the transferable lessons gleaned from hard, practical experience. On the other hand, extension should reduce the risks associated with theory testing on resource-poor farmers and encourage the use of beneficial new no or low cost inputs and locally sustainable management (Wibberley, 1995).

Generally, the role of the state in environmental governance has been shown to be minimal or on the decrease (Sonnenfeld and Mol, 2002; Jonas and Bridge, 2003; Lane, 2003) compared to that of the informal sector (Pretty and Hine, 2001; Pugliese, 2001). However, for agricultural sustainability to take hold and contribute in the quest for ensuring food security in developing countries, the bottom-up initiative of smallholders should be complimented by an equally strong 'above' impetus such as the government, research institutions and NGOs. Thus, converting Nigeria's agricultural systems to sustainable alternatives will require systematic and institutional planning rather than the

haphazard approach that presently characterizes agricultural policies. Cuba is a case in point where institutional arrangements (both state and non-state) played significant role in promoting sustainable organic agriculture. The government, through its agencies such as the *Ministerio de Agricultura* (Ministry of Agriculture, MINAGRI) and the *Sanidad Vegetal* (Plant Protection, SV), has been the significant driving force in sustainable agriculture through investment in research and extension and reform of policies, for instance with regards land tenure (Rosset and Medea, 1994; Perez and Vazquez, 2002; Funes, 2002). Also, NGOs like the *Asociación Nacional de Agricultores Pequeños* (The National Association of Small Farmers, ANAP) and the *Asociación Cubana de Técnicos Agrícolas y Forestales* (Cuban Association of Agriculture and Forestry Technicians, ACTAF) among others, promoted the adoption of agroecological principles through sustained agricultural extension services and education (Alvarez, 2002).

Given adequate funding and institutional support, Nigerian researchers have the capability to produce innovative and sustainable technologies as evidenced by the many innovative technologies wasting on shelves in these institutions across the country. The National Cereals Research Institute in Baddegi, for instance, has developed over 57 adaptive and high yielding varieties of rice (17 upland varieties, 32 lowland varieties and 3 deep water varieties) and a processing machine that turns out high quality milled rice brand of international standard (Ojo, 2008a). Similarly, the Institute for Agricultural Research (IAR) in Samaru has, since it was founded in 1924, spearheaded research in crop improvement. Their work in the area of *Striga* resistant variety can significantly lead to the reduction of chemical use among farmers in the savannah region of Nigeria.

Agricultural research and extension should not focus strictly on technical support and agricultural modernization but also on sustainable traditional agricultural practices. They should emphasize IKS and how smallholders can be supported by both the formal and informal sectors. Similarly, research should be directed at studying and recording IKS and identifying their strengths and weakness and understand its successes and its failures. The means of knowledge documentation and transfer need to be researched into in order to share such knowledge with other developing countries.

Additionally, research centres can contribute in making large-scale farms more sustainable through their research on traditional farming systems and how modern science can be applied to traditional agriculture. Such methods as biological control of pest can be used on big farms as has been demonstrated in Cuba (Altieri et al., 1999; Alvarez, 2002; Enriques, 2000; Funes, 2002). Thus, traditional methods of agricultural production can be supplemented with high quality scientific research and training in agroecological principles (with emphasis on IKS), south-south knowledge

transfer and the systematization of knowledge on sustainable traditional agricultural methods and techniques.

In the pursuit of the above considerations for alternative forms of agriculture, the role of women in agricultural production needs to be carefully considered. This requires investment in education and sensitization on gender, labour-saving technology for women (such as reducing the need for fuelwood and the drudgery of tasks such as grinding grain, water carrying, maize shelling, and weeding), strengthening of women capabilities and institutions, and defining and protecting women rights to land ownership. Also, to challenge cultural anachronism, women must build on the limited rights and privileges already in place as a means to overcoming and transforming the ideologies, attitudes, values, structures and behaviour that create hierarchical and dominating power relations in the society.

Finally, the land tenure system needs revisiting so as to make land accessible to all and to remove the monopoly exercised by a few people (such as community and political leaders) who use it as a means of political patronage or outright oppression of the weak. The Land Use Act of 1978 has largely been ineffectual in ensuring land equity. As observed by Utuama (Qtd in Akogun, 2008), the Act faces problems that include: tenurial complexities, limited access to land by federal and local governments as well as foreigners, non-implementation of land ceiling, insecurity of certificate of occupancy, inhibiting consent provisions, high cost of land transactions, unification of imperium and dominion, and non-enforcement of development permission.

CHAPTER 6

EMERGING THEORY: AGRICULTURAL HYBRIDIZATION

A THEORETICAL BASIS FOR OVERCOMING DUALISM IN AGRICULTURE

6.1 Introduction

Theory building is an important outcome of Grounded Theory. The process involves relating major categories by propositions to develop an emerging theory. The theory is therefore a network of categories. Major categories identified in this research include: traditional resource management methods; reliance on indigenous knowledge; the importance of risk management; the multiple roles of agriculture in rural livelihood; and the use and promotion of external inputs in *fadama* areas. In this chapter, these categories are related together as a theoretical framework to show that *fadama* smallholders inhabit a middle kingdom between ‘conventional agriculture’ and ‘traditional agriculture.’ First, the major divide that has characterized development discourse is briefly examined and drawing on Bruno Latour, a theory (*agricultural hybridization*) is explicated based on categories developed from data analysis. The process of theory building involves constantly validating propositions generated with raw data from the fieldwork. Also, existing and contrasting literature are brought to bear on the emerging theory in order to evaluate overlaps, differences and provide new insights (Eisenhardt, 1989).

6.2 Agriculture and the ‘Semiotic Conquest’

Much of the discourse on agriculture and agricultural development in developing countries can be placed within the great divide that has characterized development studies. Conventionally, development literature has treated agriculture as tool for economic development whose main function was the provision of resources (Reynolds, 1975). Within this model, smallholders were considered as ‘inert,’ unresponsive to innovation and therefore incapable of economic behaviour (Wharton, 1969) instead of as shrewd, experienced and economically rational (Schultz, 1964). The ‘economic growth’ model, therefore, construed ‘progress’ to be contingent on ‘modernizing’ smallholders through mechanical and biological-chemical innovations.

For instance, modernization theory argued that economic development was only possible if traditional ways of production are abandoned and modern technological methods are adopted. Predicated on Rostow’s stages of growth, development was considered a homogenous process

whereby traditional societies will metamorphose into modern ones through agricultural mechanization and commercialization. Agricultural production, therefore, became modelled on resource exploitation for the market and not necessarily for domestic food production. However, economic growth in the North did not necessarily lead to growth in the South.

Dependency theory developed in response to this failure which it largely attributed to the dependence of poor periphery states on core developed ones. It criticized export agriculture and argued that agricultural lands should be used for food production in order to reduce malnutrition. Despite this criticism, however, the requirements for agricultural progress were similar in both socialist and non-socialist economies (Reynolds, 1975) and dependency theory, like classical economic theory, saw the individual as a rational actor (Valenzuela and Venezuela, 1978). Also, both theories failed to evolve a systematic approach to environmental sustainability.

One of the effects of the modelling of agriculture in a predominantly production-oriented and industrial fashion is the declining share of labour force and the rise of labour-saving machinery. Conventional agriculture has disconnected ‘nature’ and ‘culture’ and considers them to be incompatible. It is this model of agriculture as a business and the family as a business unit (e.g. the Green Revolution models) that has been promoted in most developing countries since colonialism. The *commodification* of food means its only value is market oriented. Whereas this system sometimes increased food production per hectare and per worker, it nonetheless came with a price: erosion of sustainable traditional practices in pest and disease control and soil and water management and the adoption of environmentally hazardous agricultural methods.

This process, whereby the economy became the most important driver and measure of success over and above ‘culture’ and ‘society’ has been described by Escobar (1995) as the ‘semiotic conquest’ – the triumph of capitalism over cultural values. Agricultural intervention in Africa largely followed this path and smallholders were introduced to new agricultural values and ideologies. Land, nature and the people were disconnected leading to consequences such as environmental degradation, reduction of biodiversity, erosion of indigenous knowledge systems and poor diets (Pretty, 2002). The challenge is, therefore, that of putting back the ‘culture’ in agriculture without jeopardizing the need to produce enough food to feed the world.

6.3 Towards a Post-Impasse Development Theory: Bruno Latour and the Myth of the Great Divide

A large amount of the discourse/counter discourse in development studies over the last few decades has centred on the search for a paradigm – for instance, modernisation, dependency,

development, post-development and/or alternative development. Development, for the most part evolved from 'orientalism' and anthropology both of which studied non-Western societies (which were considered and referred to as 'primitive' and 'backward'). Thus, development theories often understood and explained both development and underdevelopment in reductionistic terms (often the market) and offered universal solutions (Amuwo, 2005). Poststructural critique of development, on the other hand, unsettled development and cast serious doubts on its feasibility. It exposed its universalistic and Western orientation and showed how it has become a tool for control of 'distant others' (Escobar, 2000). Post-development rejects development on the basis of its fundamental premises and equates it with westernization (Nederveen Pieterse, 2000).

Since the 1980s, a vacuum was created in development theory due to this impasse. This impasse was the result of several factors which include: the widening and seemingly unbridgeable gap between the rich and poor countries, the environmental cost of economic development, the decline of socialism as the solution to underdevelopment and the loss of popularity of "the great narratives." Alternative theories have sought to bridge this divide by advocating for a development that is counter to the dominant model (Arce and Long, 2000), or that which is critical and practicable (Bebbington, 2000), or that which starts with concrete issues of livelihood. Yet, in the last few decades, the anthropology of development has stagnated, seemingly incapable of moving beyond the post-structural critique of development.

Using the ideas of Bruno Latour, this chapter suggests a possible path out of the structural impasse of development anthropology. Firstly, the roots of modernity (within which the development discourse is based) are examined. Secondly, an attempt is made to dispel modernity's claim to be a separate age/phase from pre-modern, a claim which post-modernism essentially reacts and gives credence to in its own critique.

Born in 1947 in Beaune, Burgundy, Bruno Latour first trained in philosophy of religion and then anthropology. A great part of his academic career was spent analysing scientists and engineers at work in Africa (Ivory Coast) and the US (California). His work covers areas ranging from philosophy, history, sociology, anthropology of science, science policy and research management. Generally, Latour's works straddle the science-society divide. Principal among Latour's contribution to the sociology of science is his critique of 'naïve' scientific method in which, contrary to actual laboratory practice, the results of a single experiment determine the validity of theories. Together with Michel Callon and John Law, Latour is credited with the initiation and spread of actor-network theory (ANT), which is a distinctive approach to social theory that attempts to understand and explain processes of technological innovation and scientific knowledge

in terms of the infrastructure of actor-network. The Actor-Network Theory controversially integrates both humans and non-humans into the same conceptual framework and assigns them equal agency.

In the book, *We've Never Been Modern*(1993), Latour offers a dialectical critique not just of post-modernity but indeed of modernity itself. Since much of development theory is situated within a modernist discourse, Latour's critique of modernity will be taken to be an equally valid critique of development theories which compartmentalized the processes of growth into neat categories while ignoring the abiding connectivities inherent in them.

Latour debunks the 'myth' of modernity and argues against the prevalent notion that the rise of science has irrevocably changed the world and separated us 'the modern' from our predecessors, 'the premodern.' This position stems from what Latour considers to be a dual set of practice involving 'translation' and 'purification.' 'Translation' "creates mixtures between entirely two types of beings, hybrids of nature and culture," whereas 'purification', "creates two entirely distinct ontological zones: that of human beings on the one hand; that of nonhumans on the other. Without the first set, the practices of purification would be fruitless or pointless. Without the second, the work of translation would be slowed down, limited, or even ruled out" (Latour, 1993, pp. 10-11). What this means is that modernity has tried to polarize and classify ideas into 'Nature' and 'Culture,' 'Science' and 'Social,' 'Human' and 'Thing'. By their proclivity for "purification", the so-called moderns have neglected networks, the imbrolios of quasi-objects and quasi-subjects, and thereby "drained [the modern world] of its mysteries" (p. 128). This condition is, argues Latour, maintained by the four bases for modernist critique: "naturalization, sociologization, discursivization, and finally the forgetting of Being" (pp. 67, 88).

It is the inconvenient 'intermediaries,' the 'networks' that exist between the two categories ('premodern' and 'modern'), and which have been dismissed by modernity, that Latour refers to as the 'middle kingdom.' Ironically, it is within this sphere, where systems are constructed and ideas crossbred, that much of the discourses on the modern world actually take place. In this third sector, politics, science, technology, and nature are constantly mixed, making the distinction between nature and culture (with each in a separate mental chamber) illusory and difficult to maintain. Thus, modernism both purifies and hybridizes but separately and never admits to doing so nor acknowledges the interstices of nature and society in an all-encompassing reality (fig. 18). The moment modernism acknowledges this "middle kingdom" between society and nature, it will cease to be modern and collapse back into "premodern" in-differentiation.

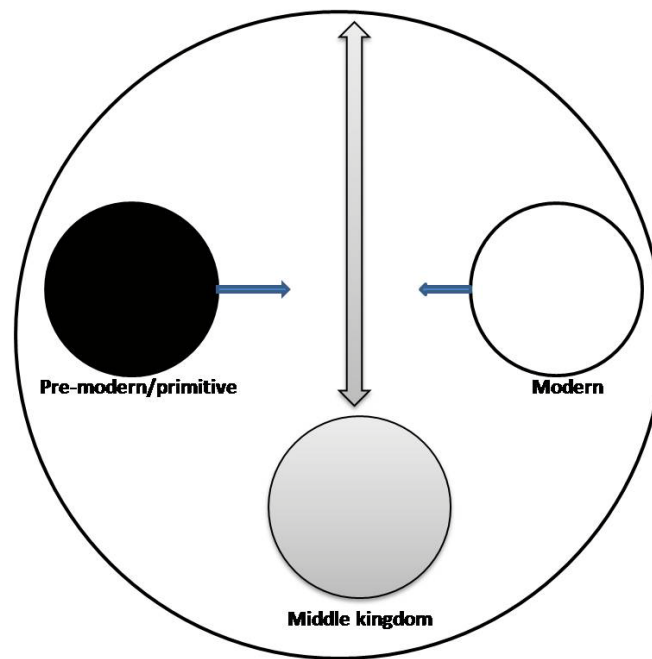


Figure 18: The great divide in modernism discourse

However, based on the proliferations of such connections (hybrids) between nature and culture, Latour argues for a rethink of the whole modern enterprise and our understanding of modernity. This can be achieved through an alteration of our mental landscape that will enable us to blur the false distinction between ideas, between nature and culture. By so doing, we can keep the best elements in modernity and replace the rest with a broader, fairer, and finer sense of possibility (Latour, 1993, p. 62). Once we become engaged in the simultaneous acts of purification and hybridization, we stop being wholly modern and our relation with other natures-cultures becomes transformed in a renewed future (Latour, 1993, p. 11).

Latour's critique of 'modernism' extends to both to 'postmodernism' and 'anti-modernism' all of which for him operate within their adversary's playing field. They both "believed what the moderns said about themselves and proceeded to affix the opposite sign to each declaration...the values they defended were never anything but the residue left by their enemies" (p. 134). In fact, postmodernism is as such a symptom and not a fresh solution as it lives under the modern 'constitution' even if it does not believe in the guarantees the 'constitution' offers (p. 46). Thus, postmodernism prolongs a critique in whose foundation it does not believe (Lyotard, 1979). Its declaration of 'no future' is simply a reverse of the moderns' motto 'no past' and in the end what remains are disconnected instants and groundless denunciations "since the postmoderns no longer

believe in the reasons that would allow them to denounce and to become indignant” (Latour, 1993, p. 46).

Latour (1993) advocates that we retain and reject selected precepts from the premoderns, moderns and postmoderns (reflexivity and deconstruction/constructivism) (p. 135). His representation of the ‘middle kingdom’ is one that reconfigures within its confines the continuity of the collective “There are *no more naked truths*, but there are *no more naked citizens*, either. The *mediators* have the whole space to themselves. The Enlightenment has a dwelling-place at last. *Natures* are present, but with their representatives, scientists who speak in their name. *Societies* are present, but with the objects that have been serving as their ballast from time immemorial” (Latour, 1993, p. 144).

Latour’s position represents a radical shift in philosophical practice and conventional thinking on the issue of modernism. His focus on connectivities and the reordering of things in space (different from the Euclidean notion of time and space as universal abstracts) has inspired scholars in fields such as geography (Bingham, 1996; Latour, 1997; Murdoch, 1998).

There is a striking similarity between Latour and the ideas of Systems and Complexity Theories¹⁶. The former focuses on the interrelatedness of the complex parts that make up a system. The relationship between these interacting parts is not additive but connected. Complexity Theory on the other hand centres on the nonlinear behaviour of the parts that make up a system and the importance of initial conditions on the overall system. Hence, a distinguishing feature of systems is that they are naturally self-organizing and cannot be controlled in the deterministic Newtonian sense. Both Systems and Complexity Theories approach the system holistically whose parts are interrelated. However, the behaviour of the whole cannot be explained simply by the behaviour of its parts. Also, both theories realize that systems have multi-level structure that can exhibit feedback-seeking behaviour (Teerikangas and Hawk, 2002).

6.4 Conventional agriculture and the Process of ‘Compartmentalization’

A holistic approach (like Latour’s) can help shed light on impasse of the current global food system. From its very foundations the scientific basis of ‘modern’/‘scientific’/conventional agriculture ignored the connection between nature and culture and production and the environment. Conventional agriculture typifies the false separation and isolation of science from

¹⁶ Hybridization was similarly anticipated by Dependency Theory especially with regards the complex nature of social formations. Categories such as ‘North’ and ‘South’ are not as neat as assumed. The so called ‘core’ North is not characterized by purely capitalist formations. Aspects such as the ‘household economy’ and underpaid migrant workers among others fall outside the scope of the monetary economy. Also, the ‘periphery’ South is equally not purely capitalist because beneath the national and international capital economy is a bulky non-capitalist model. However, Dependency Theory sometimes considered the incomplete nature of the periphery as negative and thus, it fails to take the nature of complexity in the direction of systems theory.

society typical of modernism. As such, the complex web of translations and interactions that joins these two have been completely ignored for the most part leading to the promotion of a system that exploits nature's resources without consideration of consequences on society and the environment.

Modernity's critical stance which divides and conquers hybrids through the process of purification and disciplinary 'ghettoization' has shaped much of conventional agriculture in which the delicate network that exists in nature and between nature and society (typical of traditional agricultural systems) are ignored through tidy compartmentalization. Modernism encourages us not to mix up knowledge, interest, justice and power (Hicks, 1994). Monoculture sums up conventional agriculture's tendency not to mix. Yet, as argued by Latour, the so-called premodern cultures thought and acted through hybrids. Traditional agricultural systems relied on the interrelationships that exist in the natural ecosystem and worked in line with such synergies and not counter to them. For them, the distinction between nature and culture was non-existent. Instead, there is a continuous and inter-dependent relationship between them.

Conventional agriculture has pursued a modernist agenda in focussing mainly on technical innovation and the use of external non-renewable energy sources and inputs for the sake of economic gain. Agricultural industrialization and commercialization ignored the social and ecological dimensions of agriculture. Rather than conceptualizing agriculture as *multifunctional*, extending beyond simply food production and economic gain, modernism construed agriculture as *unifunctional* and so discounted the interconnections between those multiple dimensions.

Instead of anatomizing ideas and reality, therefore, agriculture needs to explore and elaborate the relationships between them in a manner Latour describes as an ethnographic habit that deals calmly with the seamless fabric of 'nature-culture.' Thus, instead of being ghettoized and compartmentalized, useful elements of both indigenous knowledge systems and elements of modern science can be collected, sorted, elaborated and followed such that they benefit each other. This will amount to cessation of our modern posture and the dawn of a new nonmodern constitution and a new democracy which allows us to hybridize and connect the complex but valid aspects of our lives and relation to means of production such as land and water.

Latour's concept of hybridization has epistemological implications. Traditional societies and indigenous knowledge systems have been side-lined and termed 'premodern' – an antithesis of the 'modern' West's pure science. This resulted in the ascendancy of 'epistemological monoculture.' IK became a 'missing mass' which was ignored socially, politically and philosophically. However,

when construed in *Latourian* terms, this divide ceases to exist and the two knowledge systems meet in a middle discourse. Thus, the ‘Us’ and the ‘Them’ divide collapses under the ‘principle of symmetry’ which overlooks the differences between these two human constructs. Through the application of this principle, the focus shifts from pure forms (premodern and modern), which do not exist anyway, to the complex interactions of the ‘collectives’ (the entanglement of humans and non-humans) (Latour, 1993).

The ‘principle of symmetry’ eliminates the antagonism and dualism between modern knowledge/agriculture and traditional knowledge/agriculture and redistributes competencies – modern science and traditional science inhabiting the same collective (Pottage, 2001). However, this is not equivalent to relativism because in spite of its name, the principle is deeply asymmetrical putting “all the explanatory weight on society and none on nature. It doesn’t give proper weight to non-social things and processes, or acknowledges their contribution to our social arrangements” (Bloor, 1999). This means that one knowledge system (IK) is not explained in terms of modern scientific knowledge and vice versa, nor is knowledge seen as a mixture: rather, these two knowledge systems (like society and nature) must be explained at once, in terms of a third process. Thus, IK and modern science, society and nature are ‘coproduced’ (Latour, 1992, p. 287).

Furthermore, hybridization has implications on our understanding of truth and power. Traditionally, truth (Greek = *Aletheia*) has been predicated on having real knowledge or science. However, truth and history are not a reflection of an ever greater human consciousness as thought by Hegel and Kant but an attempt to accumulate and control time and space and those who achieve this achieve power. Hence, science has become a legitimizing tool for the pursuit of power. It has achieved this through oversimplification of large numbers of events and harder facts and the silencing of dissent. Thus, knowledge systems alien to the science and those not amenable to its neat system are ignored or ‘reduced’ to allow for control. Modern science and technology, therefore, have been instrumental in achieving political and economic hegemony over non-Western communities. However, the realization that this kind of thinking is harming the universe has inspired the debate for the democratization of knowledge and the construction of alternatives that are more sustainable than the ‘monoculture’ of modern science.

6.5 Achieving ‘Hybridization’ in Agriculture

In bridging the great divide in agriculture and development studies, Latour’s caution on saving the best of modernity (i.e. using science to benefit nature and not vice-versa) should serve as a guiding principle. Agricultural hybridization can happen at several levels but this needs to be done dialectically. Firstly, there can be a *hybridization of institutions* whereby traditional institutions such as

the ones in the *fadama* communities are hybridized with formal institutions. Traditional institutions are custodians of sustainable resource management practices and indigenous knowledge that could contribute in building more stable global food systems. Thus, ‘modern’/formal actors/institutions and customary institutions can result in a collaborative system of resource management in *fadama* areas. Traditional institutions that have been side-lined in the making of policy that affects smallholders in rural communities can play a vital part in the new system of multiple stakeholders advocated for here, where both institutions shape the collective destiny of the people and the environment through judicious resource management.

Equally, traditional institutions can benefit from the ‘modern’ scientific knowledge of the changing environment/climate change and changes in ecology while the latter can also draw from former’s repertoire of sustainable farming practices. For long, ignoring traditional institutions has resulted in the promotion of agricultural policies that are ineffective in resource management and the imposition of inappropriate development policies, both of which have negatively impacted the environment and the people’s livelihoods (Bromley, 1991; Crook, 2005). Many of these institutions have survived both colonialism and the post-colonial state and have been reinvigorated in light of increasing social pressures and the failures of many modern institutions. It is these institutions that ‘hybrid agriculture’ seeks to incorporate in resource management. Modern institutions can benefit from the presence and knowledge of rural communities and their institutions. On the other hand, customary institutions can also develop reflexivity and abandon certain anachronistic elements (such as land rights for women) that characterize them.

Secondly, there can be a *hybridization of knowledge* such that IK and modern scientific knowledge can draw from what is good and valuable in both systems. For instance, African agriculture has been known to be very flexible and adaptable as reflected in the adoption and success of the variety of crops that have been introduced onto the continent. Similarly, many traditional farmers not only experiment with new breeds but also combine breeds purposely to develop new strains (Richards, 1985).

The production of non-traditional fruits and vegetables has intensified since they were introduced to several African countries in the last few decades (Jaffee, 1995; Barrett et al., 1997). However, care must be taken in ensuring that commercial and export crops do not take the place of food crops. Crop diffusion should be encouraged where socio-economic benefits are apparent but crops introduced to smallholders in developing countries should find ‘their niche’ and not replace previously cultivated traditional crops (Blaut, 1977). American maize and Asian rice (*Oryza sativa*) varieties have been such successful crop. According to Richards (1996) the practice of introducing

new cultivars into existing traditional cropping systems is a 'repertoire enhancement' and a technique that can lead to local cultivars like millet taking on new roles (from staple food to specialized beer ingredient) within an emergent cropping system (pp. 312-313). For instance, in many parts of Africa (including Nigeria) maize has replaced sorghum and millet as staple food which have become crops for beer brewing (Byerlee and Heisey, 1997; Smith et al., 1997). Similarly, the International Institute of Tropical Agriculture (IITA) has recorded successes in developing new and better yielding banana and plantain cultivars (*Musa* crops) through improved breeding techniques (IITA, 2008).

In addition, African smallholder agriculture can benefit from technical innovation such as sustainable technologies for better efficiency. In addition to sustainable technology, traditional agricultural systems can benefit from sound agricultural extension on sustainable farming methods. Through such methods and consistent agroecological principles, smallholder traditional agriculture will be able to compete with agri-business. On the other hand, conventional agriculture can draw from indigenous production systems and management strategies for natural resources (soil and water).

In some instances, certain traditional knowledge systems and farming practices themselves need reforming. Traditional knowledge, which has been confined and restricted can be studied in-depth and made global such that it benefits other communities and it is equally enriched in the process. Other reformations encouraged in certain cycles include the use of bio-fertilizers and bio-pesticides alongside compost/manures and biological/cultural methods of pest control. Similarly, traditional agriculture could draw from certain management methods used in conventional agriculture.

Thirdly, there is the possibility of the *hybridization of methods*. This is perhaps the most problematic in the sense that many aspects of the methods of conventional agriculture such as the use of agrochemicals are significantly in conflict with the principles of agroecology and sustainability. The effects of modern farming methods have resulted in water pollution, proliferation of susceptible species, increased use of pesticides and soil depletion among others. These effects are undesirable and are therefore incompatible with sustainable agricultural practices. Hence, there is the need for more research in this area on the possibility of combining amenable methods of modern farming with sustainable ones not only to increase food quality and output, but also to encourage a more sustainable use of non-renewable resources, protect soil fertility, reduce pollution, ensure economic viability and exploit natural cycles.

Finally, there can be a *cross-hybridization* of *hybrids* where, for instance, modern farming methods can benefit from traditional knowledge systems. Aspects of traditional farming such as the focus on stability and risk reduction, system diversity and trophic complexity of natural systems can be valuable to conventional agriculture in achieving sustainability. Similarly, agroecology is generally high in net energy yield due to the fact that external energy inputs are relatively low. A careful study of these knowledge systems which are built and modified over centuries, can help in redesigning the food production systems in industrial countries and correct some of the deficiencies that characterize conventional agriculture.

6.6 African Smallholders and Agricultural Hybridization

In order to overcome the impasse in development, the targets of development intervention must be carefully studied in order to understand IKS and how indigenous people construct meaning. Also, it is important to understand how targets of development intervention perceive development. Often, smallholders' understanding of development/agricultural intervention in developing countries does not fit into the dichotomous, bipolar logical of development and post-development theories as evidenced in the cases of Karshi and Baddeggi. Similarly, they do not always completely share the radical democratic, anti-authoritarian, anti-capitalist and anti-imperialist concerns and agendas' of post-development theorists (Nederveen Pieterse, 1998). Instead, they balance the two and negotiate meaning when faced with development interventions.

Indigenous people adapt and recast their dependencies on modern means of production in order to reconstitute and reproduce their own cultural ideas and practices (Sahlins, 1992). Through their participation in NGO and donor-driven projects, indigenous groups draw on the modern institutions and resources of a global civil society to reconstitute themselves as a 'traditional community'. Increasingly, systems such as *fadama* agriculture, employ the tools of modern technology and politics but at other times reject or modify the paradigm altogether. In an extensive study of different communities in the Northern Cape and Northern Provinces of South Africa, (Robins, 2003) showed how indigenous peoples critically engage with development intervention and reorganize it depending on specific content and context. This process has been referred to as the 'indigenization of modernity' (Robins, 2003).

The 'agency' exercised by traditional societies in negotiating modernity and the fact that they inhabit a 'middle kingdom' (between premodern and modern) have largely been ignored both by development theories and policy makers. Development theory has operated on the basis of the dichotomy between 'modern' and 'traditional'. Similarly, critics of mainstream development have fallen victim to this categorization. Both development (mainstream) and post-development

theories “assume a taken-for-granted stance that development discourses and bureaucratic state practices are in fact the all-powerful and uncontested discursive conduits for the spread of Western modernity, global capitalism and neo-liberalism” (Robins, 2003, p. 270). Thus, they both not only ‘over-emphasize the reach and capacities of both the state and development’ but they also ‘seriously underestimate the capacity of beneficiaries and citizens to strategically engage with the state and development’ (Robins, 2003, p. 271).

This position totally discounts the hybrid nature of reality of life in postcolonial Africa. Local communities embrace, reject or modify the development discourse to suite their local context and history. In fact, the failure of mainstream development intervention in many developing countries cannot be totally disengaged from this agency exercised by traditional societies in their rejection, resistance and/or modification of ‘development,’ especially elements they consider to be too extraneous and contradictory to their accumulated knowledge systems.

The hybrid character of many indigenous societies makes the dichotomy between ‘modern’ and ‘traditional’ redundant as it is impossible in most cases to speak of strictly ‘modern’ or ‘traditional’ societies. The so called ‘traditional societies’ transcend these two epistemological categories because of their hybrid nature. Not only do many smallholder farmers in developing countries use machines and external inputs such as agrochemicals, their access to modern instruments such as mobile phones defies the pure categories claimed in development discourse.

If the divide between ‘modernity’ and ‘tradition’ as claimed in much of development discourse is exaggerated, and if practices of traditional farming communities do not fit into the pure categories supposed in theories, then it is the sphere of interaction and connectivities (the middle kingdom) that need careful studying. It is presumptuous to talk of closed farming systems as interaction and influences of outsiders always causes some differences in the resource base of farmers and this often results in transformation of their farming systems. Hybrid research, therefore, aims to strike a balance by providing a common ground on which post-development and the neo-populist paradigm of development practice can converge and benefit from mutual engagement.

In agriculture, hybrid development will strive for systems where limited and sustainable external material inputs are combined with local knowledge resulting in an exchange of local knowledge and external know-how. Hybrid development, which is the synthesis that stems from this engagement, brings together the two epistemologically conflicting and divergent views in a critical way to produce a *midterm* discourse, that is, a meeting point of minds ‘where the grassroots and official society come together and gradually develop a more general social project’ (Biel, 2000). One such

sphere of dialogue, for instance, can be in the area of technology blending as shown above. Development experts should work towards understanding this dynamic while being careful to overcome an ‘unbiased glorification of communities and ‘the local’ at the expense of a differentiated, radical view of development processes” (Müller, 20036, p. 314).

CHAPTER 7

THE SUSTAINABILITY AND SECURITY OF THE GLOBAL FOOD ECONOMY

7.1 Introduction – Chapter Focus

The purpose of this chapter is to build a theoretical framework for interpreting the significance of findings from the research as reported in the previous chapters. This is line with the Grounded Theory methodology adopted in this research. Whereas substantial literature was accessed during the research with particular reference to findings, this chapter has a broader scope and places the results and findings from the fieldwork within a global framework.

During the last 3-4 years, food security has arisen as a major issue around the world. This was precipitated largely by an unprecedented rise in the price of cereals between 2007 and 2008. Prior to this, it was widely accepted that food insecurity was not caused by limited amount of agricultural land and high population growth as postulated by Malthus but by wider socio-economic factors like distribution. However, the resurgence of absolutely deficient production and changes in climate, among other factors, have once again reignited the debate on the link between food insecurity and global productivity. Both agricultural productivity and food security are directly affected by the acceleration of environmental degradation and climate change. The recent food crisis has thus raised wider issues regarding the global food system and it is increasingly accepted that it is highly imbalanced, unstable and unsustainable. The ability of conventional agriculture, characteristic of this system, to meet rising global food demands has been questioned due its excessive dependence on expensive external inputs and its harmful effects on both the environment and human health.

It is against this background of food shortages and change in climate pattern that the role of smallholders is assessed. The promotion of a specific type of agriculture, i.e. industrial or conventional agriculture, has significantly impacted on and sometimes eroded traditional agriculture as important aspects of traditional agricultural systems were sacrificed in the pursuit of productivity. This type of agriculture has also resulted in the depletion of resources and the destruction of ecosystems. Moreover, through the predominance of the globalized commodity trade, the food system has resulted in the integration of the food supply chain and its concentration in the hands of a few transnational corporations.

It is argued in this chapter that in light of the crisis facing the global food system, a fundamental shift in human management of ecosystem must underpin an acceptable future food economy. Ifin

an obsession with the increase of productivity, we fail to address the problems facing the global food economy or marginalize them, we risk making things worse. As suggested by the International Assessment of Agricultural Science and Technology (IAASTD), we must focus on rehabilitating and overhauling the food system with the central aim of building the resilience of socio-agricultural systems in the face of shocks. Agroecology is therefore offered as an alternative model of agrarian production with specific reference to the role of smallholders and indigenous knowledge in constructing this alternative model. Despite changing and challenging environments, smallholders, especially women, have a central role to play in promoting food security. Through the use of agroecological principles, smallholder farming systems provide synergistic benefits that include mitigating climate change and reducing the adverse impacts of conventional agriculture on the environment.

7.2 Evolution of Perspectives on Food Security

In his seminal essay on population growth and hunger, Malthus theorized that given growing population and the increasing scarcity of land, the inevitable outcome would be increased hunger, famine, disease and hence death (Malthus, 1976). Subsequently, the rampant problems of food shortage and famine such as the unprecedented hunger that overwhelmed India, China and Brazil were blamed on the inability of food production to meet with the demands of increasing populations (Davis, 2001). The Malthusian argument became dominant providing “a natural law for inequality and the misery of the masses” and tremendously influenced the likes of Charles Darwin (Evan et al., 2009). The ideas of Malthus took a stronghold in Victorian England and filtered into political opinion (Seidl and Tisdell, 1999). In the early 20th century, the Malthusian argument was revived by John Maynard Keynes who drew on Malthus to explain food and fibre shortage during the First World War and Garrett Hardin who also used the Malthusian logic in arguing against helping the poor. Other use of this logic in the 20th century is the utilization of computer models to show the impact of population growth on food availability in the future.

However, the classical Malthusian perspective and its modern variants that suggested absolute food deficiency were challenged from several directions. One such important non-Malthusian perspective argued that due to its historical reality (i.e. steady-state economy with modest technology), traditional Malthusian analysis grossly ignored the role played by technology and innovation in multiplying food production. Subsequent trends have not only demonstrated growth in food production, they have actually proved that in some instances, new technological innovations, such as terracing hillside, were inspired by extra populations (Boserup, 1981).

The development of the tractor and the manufacture of the nitrogen fertilizer in the early 20th century subsequently shaped agriculture (Collings, 1995). With increasing world population, industrial agriculture, based on high external input systems, significantly led to an increase in productivity and became the surest way of combating hunger. The Green Revolution in India, for instance, brought about an unprecedented increase in food production from 95 million tonnes in 1967 to over 200 million tonnes in 2000 without significant increase in net cultivated area (FAI, 2004). With the proliferation of technologies in the 20th century, it was assumed that the threat of serious hunger had been completely eliminated. The UN declared food a basic human right and in 1996, The Rome Declaration on World Food Security and Plan of Action predicted that agricultural output will pick up and grow by 1.6 per cent a year [from 1999] to 2015, outstripping predicted world population growth of 1.1 per cent a year. Due to the technological innovation and the accompanying improvements in food production, therefore, human populations in many parts of the world enjoyed healthier and longer lives (Simon, 1981).

Another approach questioned the Malthusian-inspired notion of earth's carrying capacity and argued that it is flawed in that it presupposes that environmental conditions are constant and technology stable. In reality, argue modern ecological theorists, environmental conditions are in a constant flux and hence calculating a region's maximum capacity is not as easy as suggested by traditional Malthusian logic because people's choices and dietary patterns are in themselves not constant (Cohen, 1999; Vetter, 2005).

In light of the above, the debate in food security largely shifted from methods that dwelt more on analysing food production patterns to demand-oriented methods that explored the socio-economic context within which consumers obtain food. Two categories of the demand-oriented methods are the 'non-welfarist' category and the 'welfarist approach' category (Evan et al., 2009, 2070). The first category used extensive data and categorized people as nutritionally poor based on international or externally decided health standards such as comparisons between a children's weight and its age. In contrast, the 'welfarist approach' described poverty in terms of the people's perception of their welfare. Critics of the demand-oriented method argued that it is laden with methodological complications that make it hard to implement in the field. Similarly, it has been argued that it provides policy makers with data that have little functional value. In other words, not only does it gloss over the causes of hunger are, it does not help in identifying guidance as to how problems of hunger and malnutrition can be solved (Foster, 1992).

Participatory approaches arose in opposition to the demand model and instead focused on the relationship between welfare and the preferences of individuals. This approach is predicated on the

logic that “utility function” is important and takes precedence when people order goods in a preferential manner. This assumes that people compare the cost and benefits of their actions and are able to recognize, order and choose between options available to them (Ravallion, 1994). Its major improvement on the preceding model is that the decision on the desirability of food security policy options lies with the people and not experts. Located within the broader trend in social sciences, participatory methods seek to focus on local factors rather than meta-narratives or all-encompassing explanatory theories. Advocates argue that understanding the local is necessary, if not mandatory, to understanding and engaging with the global. Stressing on objective indicators, argues this position, may actually reflect the condition of the researcher rather the problem *per se* (Escobar, 1995; Morse and Fraser, 2005). Despite its desirability however, critics have maintained that the people are not always necessarily better placed to make decisions about their welfare and individual choices sometimes have the potential to harm the welfare of the community. Similarly, participatory approaches are cumbersome and costly making them hard to organize or facilitate (Ostrom, 2001; Stringer et al., 2006).

Another non-Malthusian approach that seeks to avoid some of the pitfalls of the other methods described above is the capability approach which focuses on the people’s ability to meet their needs. The best advocate of this approach is Amartya Sen who stressed the importance of factors and ideas hitherto ignored in welfarist theories. These ideas included the significance of real freedoms in gauging a person’s advantage, differences in the ability of individuals to convert resources into valuable activities, the importance of welfare distribution and the multiple factors and activities (material and non-material) that determine human welfare and happiness. For Sen, what is important is the extent to which families are able to undertake those specific objectives that are useful to them (Sen, 1982; Sen, 1987). By emphasizing on freedom, this approach shifts attention from presuppositions on what type of food people should be eating to what they are actually eating. Some have criticized this approach for its undue emphasis on economic indicators and traditional methods of poverty assessment. Thus, it is said not take into account the role of women and non-cash methods in attaining food security (Ravallion, 1996; Haddad et al., 1997).

In response to these difficulties, Sen studied the several ways in which people actually obtain food. He used the term ‘entitlement’ to show that food shortage results not only from a lack of food but even more importantly as a result of inequalities in distribution. In order to understand ‘entitlement failure,’ argues Sen, a combination of economic, human, social and natural capitals must be considered. According to Sen, when an individual’s entitlement or that of the community is upset, the result is famine or severe malnutrition. Contrary to Malthusian assumptions and the food

availability decline approach, Sen argues that it is not food availability that determines famine but the pattern of people's entitlement to acquire food. This can result from loss of purchasing power through "unemployment, falling wages, rising food prices, or inflation [and inability to access] assets to either grow food or rely on others for charity (Sen, 1988). In a study of four famines (the Great Bengal famine (1943), the Ethiopian famines (1973-1974), the Sahel famines (1970s) and the Bangladesh famines (1994), Sen showed that the collapse of entitlements among certain sectors of the population rather than availability led to famine. Sen's entitlement theory culminated the other perspectives such as the "sustainable livelihoods approach" which focuses on the role of 'capital asset' (such as social, human, financial, physical and environmental) and wider contextual issues (floods, droughts, environmental decline and population change) in maintaining food security (Scoones, 1998; Bebbington, 1999). It also stresses the importance institutional processes in food security. In general, it became widely accepted that food scarcity is mostly a function of socio-economic factors.

7.3 The Global Food Situation – From Abundance to Crisis

As shown above, the focus of development discourse over the years shifted from the strictly Malthusian logic that stressed food availability decline to perspectives that centre on specific socio-economic context of consumers as a solution to malnutrition. However, over the past few years, a major shift has occurred and the spectre of absolutely deficient production has once again surfaced. By 2003, the FAO admitted that the number of people without enough food to eat on a regular basis remains persistently high, at over 800 million, and it is not falling significantly. Over 60% of the world's undernourished people live in Asia and quarter in Africa. The proportion of hungry people is greater in Africa (33%) than Asia (16%). In general, "the countries that succeeded in reducing hunger were characterised by more rapid economic growth and specifically more rapid growth in their agricultural sectors. They exhibited slower population growth, lower levels of HIV and higher ranking in the Human Development Index" (FAO, 2003c). By 2007, the FAO emphasized that 36 countries were in crisis in terms of food security, of which 21 were in Africa. It also admitted that the capacity of international relief agencies is barely able to feed 10 per cent (100 million people) of those who are hungry (Evans, 2008).

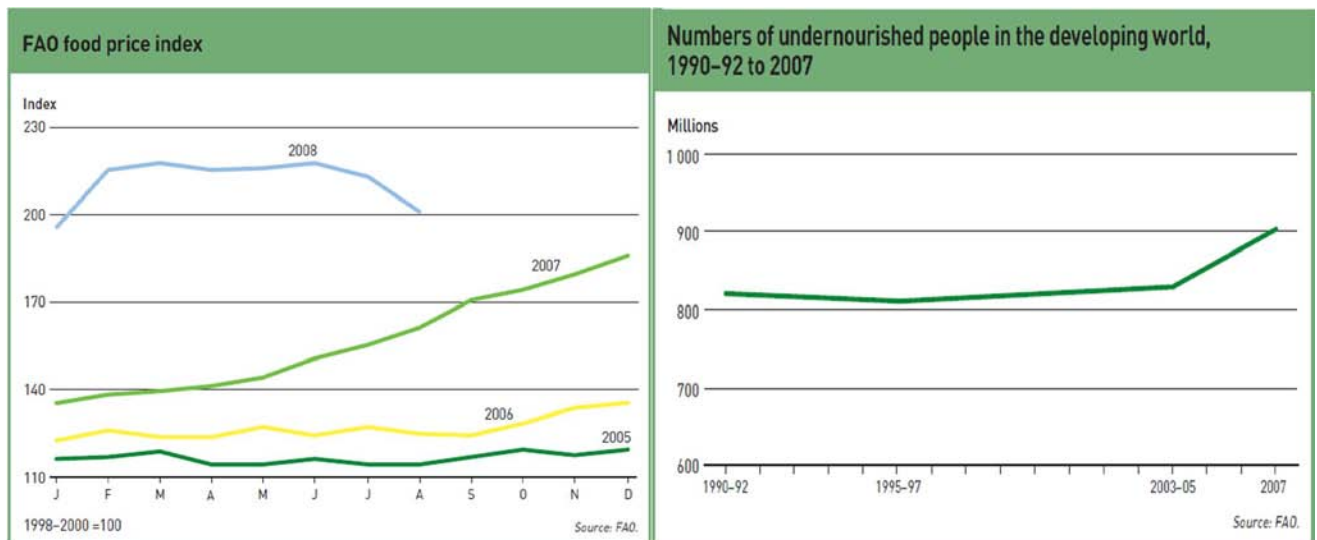


Figure 19: State of food insecurity in the world, 2008
Source: (FAO, 2008c)

Decades since the advent of industrial agriculture, therefore, the global food system has run into serious crisis with increasing number of poor and hungry people especially in developing countries. This is despite the increase in the quantity of food produced globally. One of the abiding paradoxes in the global food economy is that scarcity has persisted in the midst of plenty. It is estimated that 1.2 billion people live on less than \$1/day; over 800 million of them suffer under-nutrition or hunger. Another 2.7 billion people live on less than \$2/day (Thompson, 2008). Millions of people have been pushed to hunger because of their inability to access the available food supply due to lack of purchasing power. This simultaneous pole of obesity and hunger in a market driven food economy has led to serious questions about its ethics and overall tenability and sustainability (Weis, 2007).

Recent protests in many developing countries¹⁷ as a result of sharp fluctuations in food and fuel prices have been cited as an indication of the problem facing the global food system (FAO, 2008c). Between January and February 2008, the prices of corn increased by 131%, wheat by 117% and rice by 62%. Similarly, between December 2005 and March 2008, the prices of soybeans rose by 175%, while coconut and palm oil rose by 175% and 153% respectively (Paul and Wahlberg, 2008).

¹⁷ Haiti, Mexico, Egypt, India, Burkina Faso, Indonesia, Somalia, Cote d'Ivoire, Ethiopia, Cameroon, Senegal, Pakistan and Bangladesh among others.

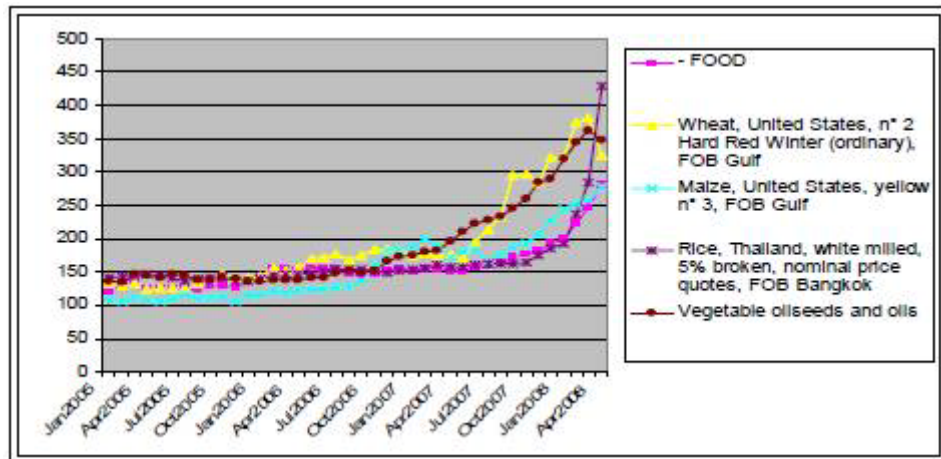


Figure 20: Monthly prices of selected food products and product categories, index numbers 2000=100, January 2005- April 2008
Source: (UNCTAD, 2008b)

The result of these increases was an unprecedented rise in the number of hungry and poor people. The United Nation's Food and Agriculture Organization (FAO) estimates that in 2008, due to increase in global food prices between 2003-2007, over 923 million people are now suffering from hunger (FAO, 2008c) (fig 20). This represents an increase of over 80 million to the figures since the 1990-1992 base period. Thus, in 2008, additional 24 million were plunged into hunger in Africa which, together with Asia, account for more than three quarters of the developing world's Low-Income Food Deficit Countries (LIFDCs). More than 89% of the total numbers of the hungry people in the world are from sub-Saharan (SSA) Africa¹⁸, Asia and the Pacific. The estimated number of hungry people in Africa in 2008 is over 212 million. The 2008 Global Hunger Index (GHI) scores Africa and South Asia as the worst hit in the world (23.3 and 23.0 respectively). Nine¹⁹ of the ten countries with the highest level of hunger in the world are in Africa where no country has shown significant improvement in reducing hunger since 1990 (Von Grebmer et al., 2008, p. 45).

¹⁸ Whenever 'Africa' is used throughout this thesis, it is to refer to sub-Saharan Africa unless where otherwise stated

¹⁹ Among which are the Democratic Republic of Congo, Eritrea, Burundi, Niger, Sierra-Leone, Swaziland, Guinea Bissau, and Zimbabwe

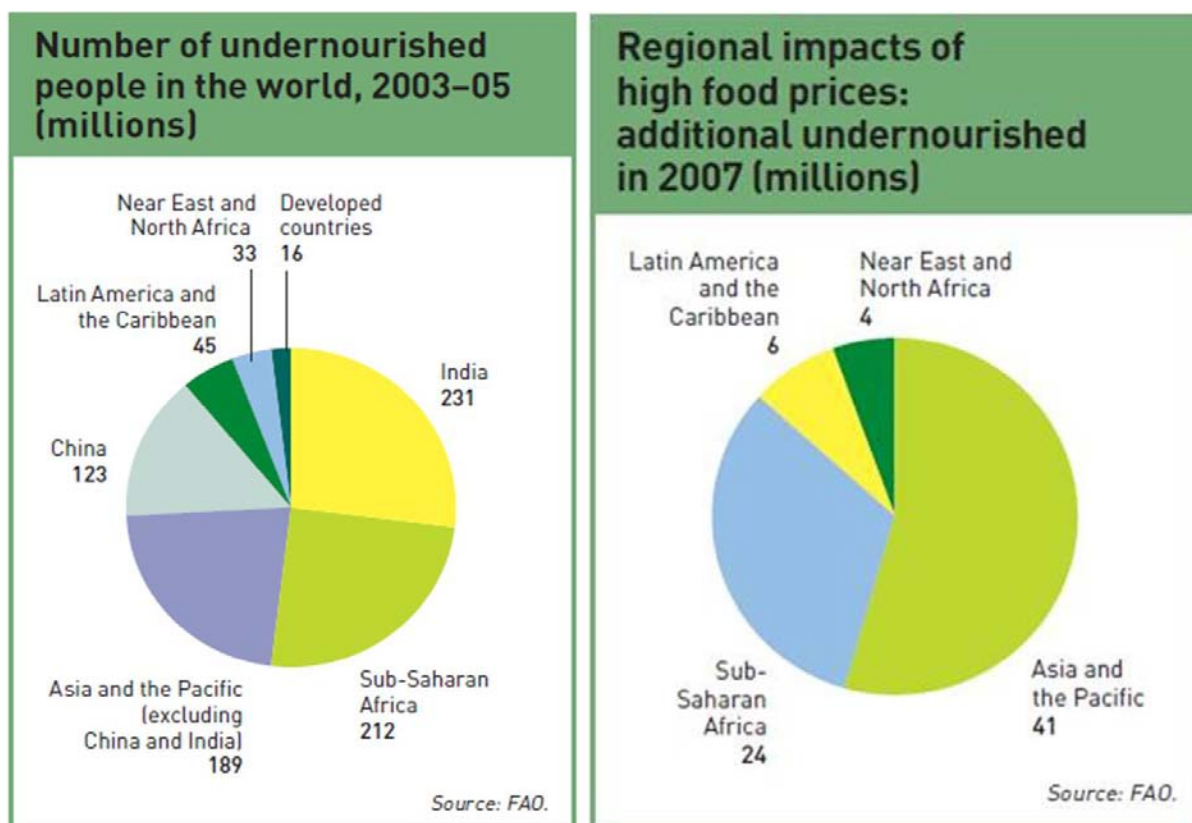


Figure 21: Regional distribution of undernourished people in the world
Source: (FAO, 2008)

It is against this background of deficient production and rising poverty/malnutrition that global food economy is analyzed and the principles underlining it examined. Also, within this context, the role of smallholder agriculture (such as those encountered in this research) in food security is assessed. These poor smallholders in developing countries, the landless and female-headed households, mostly living in rural areas are the worst victims of hunger (FAO, 2008c). For instance, an analysis of survey data for the 1980-1998 period revealed that rural poverty in Africa (whether measured by income/consumption data or other indicators) has been and remains higher than urban poverty (IFAD, 2001). Hence, not only does SSA have the one of the highest percentages of poor people, most of the poorest households are found in agriculture (Spencer, 2002; Alayande and Alayande, 2004; Poulton et al., 2005). Whereas the proportion of the people living in poverty in smallholder farming has slightly declined in Asia, it has increased in SSA (fig 22) (Johannesburg Summit, 2002; Chen and Ravallion, 2004; Lipton, 2005a). Africa's rapid population growth – an increase of 200 million between the early 1990s and 2003-2005, to 700 million – coupled with deficit in agricultural production places it at the centre of the crisis as food production has not kept pace with population explosion.

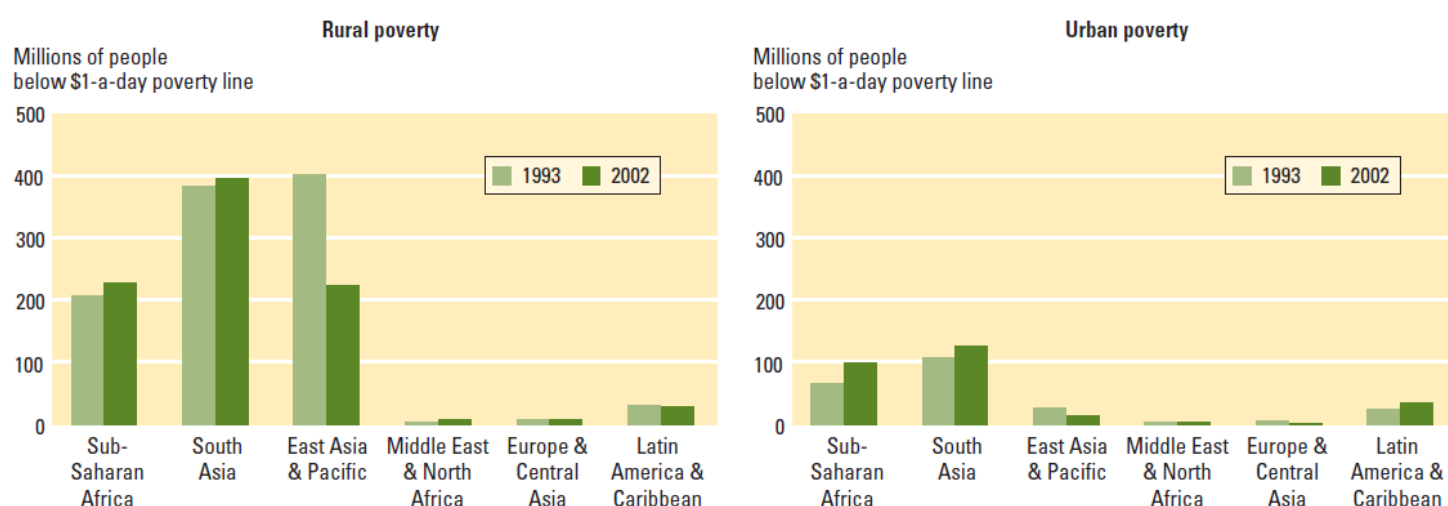


Figure 22: The number of poor rose in South Asia and Sub-Saharan Africa from 1993 to 2002 (\$1-a-day poverty line)
Source: (World Bank, 2007b)

7.4 Explaining the Food Crisis and its Implications for Smallholders

The key question that arises from the foregoing is what is/are the cause/causes of the food crisis? There are broadly two groups of explanations to the global food crisis. The first group consists mostly of development economists who are mostly concerned with identifying the specific causes of the crisis using formal research methods. According to this group, the following factors underlie the crisis: poor crops around the world in the last two years, the rise in oil prices (ADB, 2008; Alexendratos, 2008; Trostle, 2008), the use of food for fuel especially in the US and EU (IMF, 2006; FAO, 2008b; FAO, 2008a; Lipsky, 2008; Mitchell, 2008; OECD, 2008; Rosegrant, 2008; Trostle, 2008; World Bank, 2008a), depreciation of the US dollar (Alexendratos, 2008; FAO, 2009; Mitchell, 2008; Timmer, 2008), minimal worldwide stocks of grain, commodity speculation (Clapp and Cohen, 2009; Margulis, 2009), the dominance of agro-companies on the world's food systems, population explosion, higher consumption patterns in emerging economies (IMF, 2006; IMF, 2008a; IMF, 2008b; IFPRI, 2008), the deregulation of agricultural market (Lustig, 2008; Paul and Wahlberg, 2008) and trade policies (e.g. export restriction), (Dollive, 2008; Mitra and T., 2008; Mielke, 2008; World Bank, 2008b). Some factors such as poor weather and low stocks have been questioned by recent analysis (Headey and Fan, 2009) and the role of the increase of demand animal protein in emerging countries as a contributing factor to the crisis has been equally challenged.

However, a second body of research, deriving from diverse academic disciplines and relying on a multiplicity of research methods, argues that the above factors were mainly triggers underlining a

deeper problem both with the global food system and development strategy. Supported by international studies, they emphasize long-term explanations (FAO, 2008c; FAO, 2008a; UNCTAD, 2008a). Their explanations for the food crisis include these factors: decline in farm productivity in the South due to reduced investment in research, extension and basic inputs (FAO, 2008b; FAO, 2008a; Bage, 2008; IATP, 2008; Oxfam, 200; World Bank, 2008a), the effects of deregulation (under structural adjustment and multilateral trade agreements) and focus on export trade markets which have increased poverty, destroyed the environment and increased dependence of food import (Akram-Lodi, 2009; Bello, 2009; Conceicao and Mendoza, 2009; Holtz-Giménez, 2009; McMichael, 2009; Mittal, 2009), the impact of climate (WFP, 2009) and the fragmented nature of international agriculture and food governance (Clapp and Cohen, 2009; McCalla, 2009). The conclusion drawn by this group is that the global food system has been built on insecure grounds and has relied on cheap sources of non-renewable energy. Hence, it is vulnerable to environmental and economic shocks arising from the “risks, inequities and externalities inherent in food systems that are dominated by global industrial agri-foods complex” (Holtz-Giménez, 2008). Thus, the food crisis is actually the result of an inevitable downward trend - the result of a cumulative failure of governments and development agencies (Holtz-Giménez, 2008).

Despite their differences, these contending perspectives have certain fundamental agreement on key issues relevant to this research. Both have raised important questions about the sustainability and stability of the global food economy. They equally agree that the problem of food security is real and so is the challenge of finding a lasting solution to the global food crisis. More importantly, there is consensus that the food crisis and indeed the crisis in the global food economy is not over yet but that it is actually likely to deepen if not quickly addressed. This is because the structure of the global food system as it is highly unstable. Located within the modernist paradigm that emphasizes agricultural modernization through inputs supply as a prerequisite for food self-sufficiency, the global food system, while improving food supply in the short-term, has subsequently undermined productivity and sustainability and has negatively impacted on smallholders. Conventional agriculture has sacrificed some of the best practices of traditional smallholder agricultural systems such as low throughput, resilience of agricultural systems, water management, advantages of organics, diversity of strains and crops, link with wider ecosystem, diffused knowledge, attractiveness of agricultural livelihoods particularly to younger generations, validating women's role and resilience of the wider economy which prevents it from being exclusively dependent on external food supply or on demand for agricultural cash-crops. Instead, efforts were geared towards transforming and modernizing smallholders especially in developing countries. In sub-Saharan Africa, for instance, the Structural Adjustment Programmes (SAPs) and

the Green Revolutions (GRs), often promoted export crops and discouraged the mainly food-based smallholder agriculture. By undermining indigenous agricultural systems, conventional agriculture equally weakened their ability to sustainably increase productivity. In the end, the results have been unprecedented rise in urban population, unemployment, greater food imports, decline in food production and increased poverty. Also, through policies such as unfair trade terms, Northern subsidies to agriculture and reduced food aid, indigenous Southern food systems have been undermined. The food crisis has shed light on the need not just for input supply but also for appropriate policies and institutions that support smallholder producers.

Furthermore, regardless of methodological differences, there is a wide consensus that developed countries have greater responsibility for the food crisis but that its effects are worse felt by those in low-income countries such as smallholders. Despite the potential of the crisis to benefit smallholders, it has had devastating impact on low-income people in developing countries who spend the largest fraction of their income on food. The relationship between hunger and poverty is well established and two-fold. Insufficient income severely limits individual and household's ability to purchase food. Conversely, hunger lowers labour productivity, reduces resistance to disease and depresses educational achievements and thus contributes to poverty (Dixon et al., 2001). As well as increasing the incidence of poverty in developing countries, food scarcity damages human capital and slows down long-term growth. Similarly, as widely experienced at the height of the food crisis, food shortage leads to: rise in social unrest and conflicts; increased difficulty in food relief planning; significant rise in inflation and its effect on macroeconomic and policy planning; increased government intervention in the market leading to more mistrust of the market (Lustig, 2008). In general, the crisis in the global food economy has had devastating consequences on poor smallholders around the world especially those in Africa plunging them into more hunger and poverty. In the same way, instead of strengthening investment in smallholder agriculture, the crisis has worsened the condition of farmers as governments in developing countries invested more in food import rather than reinforcing local production. As revealed in the research results in Chapter 5, Nigeria continues to approve huge sums of money for greater food import rather than for improving smallholder food production. In light of these, both perspectives agree that global food economy is unstable and does not ensure justice and security for all.

7.4 Analysing the Sustainability and Stability of the Global Food Economy

In this section, some of the major themes identified above are further developed. The dynamics of the global food system at different scales are explored to show the challenges it faces with special reference to smallholders in developing countries. This is done from three standpoints:

consumption, production, the environment and trade. The implications of transformations in food consumption preferences will be discussed as well as their implications on food production and access. Also, the production side of the global economy is discussed in order to show the challenge of doubling global food production in an era of climate change, demographic pressures and related constraints. With regards trade, the role of domestic agricultural policies in distorting patterns of production will be discussed as well as the effects of these policies on developing and low-income countries. Based on the foregoing evaluation, the section concludes that conventional agriculture has reached its limit because it undermines the ecosystem, the basis of social and material relations in today's society. What emerges from the analysis is that the different aspects of the globalized and industrialized food economy have not benefitted the majority of smallholders in developing countries neither have they solved the problem of persistent poverty. On the contrary, they have negatively impacted both on smallholders and the environment.

7.4.1 Consumption – Impact of Income and Population Growth

There are significant differences in diets across countries worldwide and they change with changes income, growth, urbanization and international communication. Generally, economic development is followed by improvements in food supply and overall nutrition of a given country's population. It also transforms production, processing and distribution (Spedding, 1990; Guo et al., 2000; Popkin, 2001). Other contributing factors to changing global food consumption patterns include demographic shifts, urbanization, improved transportation and consumer perception of food quality and safety (Regmi, 2008). Transformations in dietary patterns impact on agricultural trade in developed and developing countries. In developed countries, there has been an increase in imports of high value and processed food products due to higher demand for better quality and labour saving products. In the US for instance, there has been a significant increase in per capita consumption of poultry and fruits and vegetables but a decline in per capita meat consumption between 1970 and 2000 (Haley, 2008; Pollack, 2008b). Also, there has been a major shift to organic production of food in developed countries during the last 20 years because of the increased perception that organic food and humanely raised animal products are healthier (Regmi et al., 2008).

In developing countries (where traditionally a greater portion of the budget is spent on staple food products such as cereals) however, higher income has resulted in more demand for meat products leading to increased import and trade in livestock feed (feed grains and protein meals). Urbanization, which often results in higher disposable income, is said to contribute significantly in changing global food consumption patterns in developing countries and urban population is

expected to double to nearly 4 billion by 2020 (Regmi and Dyck, 2008). Thus, increase in income (\$2 to \$10 per day) causes rapid growth in raw agricultural commodity demand as more people eat meat, dairy products, vegetables and edible oils.

Country	Population	% <\$1/day	% <\$2/day
China	1318	9.9	34.9
India	1132	34.3	80.4
Indonesia	232	7.5	52.4
Brazil	189	7.5	21.2
Pakistan	169	17.0	73.6
Bangladesh	149	41.3	84.0
Nigeria	144	70.8	92.4
Philippines	85	14.8	43.0

Table 33: Huge growth in food consumption expected from economic growth
(Source: World Bank, *World Development Indicators* database)

Whereas in some few instances changing food consumption patterns has presented an opportunity for smallholders in developing/poor countries to diversify away from ‘traditional’ agricultural commodities and into new high-value agro-export production, this is often at the behest of wholesale suppliers and corporate retailers. While in itself not bad thing, it often results in these actors exercising enormous influence over distant farming systems (e.g. horticultural and fruit expansion in Kenya and Chile). There are growing concerns on the viability and sustainability of this process and the impact of such improvements in productivity on social, economic and environmental resources (IAASTD, 2009). The consequences of this process in developing countries includes diversion of land, water, labour and other resources into production for export rather than food staples for domestic consumption. Some agri-commodity cycles (characterized by over-supply, higher transport costs and price squeezing by retailers) also expose smallholders and rural dwellers to indebtedness and result in the loss of livelihoods (Roberts, 2008).

As a result of the globalization of the food system, nutrition transition is becoming a major problem in many urban areas of middle to low-income developing countries. There is an increase in the consumption of edible oils and foods of animal origin, as well as the general sweetening of food supply (Popkin, 2005) which undermines the hitherto healthier even if scant traditional diets. This displacement in dietary patterns to high calorie, nutrient-poor processed foods, has serious implications in terms of health outcomes, risk factors and economic growth. For instance, it is creating conditions for obesogenic environments especially within the context of

increasing urbanization, unexacting forms of employment, the prevalence and preponderance of global supermarket chains, advertising aimed at the young and absence of food marketing regulations (Hawkes, 2006; Hawkes, 2007).

In addition to changing consumption patterns and dietary demands, population growth will have momentous impact on food demand. Although the rate of population growth is expected to decline, it is projected that by 2050, there would be a 50% increase in world population growth, all in developing countries and another 50% increase in broad-based economic growth in these low income countries. According to the WB, by 2030, the number of people in developing countries living in households with incomes above \$16,000 per year will rise from 352 million in 2000 to 2.1 billion in 2030 (Thompson, 2008). Due to this increase in population and income, it is estimated that by 2050 world food demand could double. Correspondingly, population and income growth will increase demands for other items like paper, furniture and building materials thereby placing more demand on forests.

Region	2007	2050	
World	6,671	9,191*	+ 38%
High Income	1,223	1,245	+ 2%
Low Income	5,448	7,946	+ 46%
Africa	965	1,998	+107%
Asia	4,030	5,266	+ 31%
Latin America	572	769	+ 34%
North America	339	445	+ 31%
Europe	731	664	- 9%

Table 34: Projected Population Growth (U.N. medium projections, in millions)

*The UN Population Office's low and high projections of the world population in 2050 are 7.8 billion and 11.9 billion, respectively.

Source: (Thompson, 2008)

From the foregoing, it is clear that global forces, like changes in consumption patterns, are affecting the evolution of the global food system. Equally important in the transformation of the global food system are by local factors such as changes in demographics. The resulting impacts on smallholder farmers and consumers are not always positive as seen above. Importantly, based on demand trends and projections, the global food system faces significant challenges.

7.4.2 Production

The global food economy is faced with the challenge of doubling global production by 2050. As shown above, contrary to Malthusian projections that population will outgrow food production, agricultural research had increased agricultural productivity resulting in surpluses and a 150 year

decline in the real price of grain. However, the future of the global food economy will bring crucial competition for resources (land and water) between food/forest production and environmental conservation (Thompson, 2008). Already, in many low-income countries, food consumption has outstripped production due to population growth, urbanization and broad-based economic development. These countries are being transformed into net food importers. Thus, food production has and will continue to exert considerable pressure on scarce natural resources (Sivakumar and Valentin, 1997).

The ability to produce food to meet growing urban populations and changing consumption patterns is constrained by land availability. Soil and environmental degradation have continued and according to Thompson (2008), there is at most 12% more arable land available that is not presently forested or subject to erosion or desertification. This severely restricts agricultural production and the possibility of doubling the area of land in farm production could result in environmental disaster – massive destruction of forests and wildlife habitat. Some have argued that “the only environmentally sustainable alternative is to at least double productivity on the fertile, non-erodible soils already in crop production” (Ibid.)



Figure 23: Constraints on world agricultural production
Source: (Thompson, 2008)

Another important constraint to food production is climate change and experts predict that global warming will severely impact on agriculture. The science of global warming remains unsettled and there are divisions regarding its causes, level and incidence of impacts (Tweeten,

2008). However, according to the world's leading scientists under the auspices of the Intergovernmental Committee on Climate Change (IPCC),

...for the next two decades a warming of about 0.2 °C per decade is projected for a range of emissions scenarios. Even if the concentrations of all GHGs and aerosols had been kept constant at year 2000 levels, a further warming of about 0.1°C per decade would be expected. Afterwards, temperature projections increasingly depend on specific emissions scenarios. Since the IPCC's first report in 1990, assessed projections have suggested global averaged temperature increases between about 0.15 and 0.3°C per decade from 1990 to 2005. This can now be compared with observed values of about 0.2°C per decade, strengthening confidence in near-term projections (IPCC, 2008, p. 45).

Some experts predict no major change in global food output aggregate due to global warming as expansions in northern regions such as Canada and Siberia is expected to compensate for contraction in tropical and sub-tropical Africa and Asia. According to these experts, over approximately one century,

...global crop productivity is projected to increase slightly at mid- to high latitudes for local mean temperature increases of up to 1 to 3°C depending on the crop, and then decrease beyond that in some regions. At lower latitudes, especially in seasonally dry and tropical regions, crop productivity is projected to decrease for even small local temperature increases (1 to 2°C), which would increase the risk of hunger. Globally, the potential for food production is projected to increase with increases in local average temperature over a range of 1 to 3°C, but above this it is projected to decrease (IPCC, p.48).

However, “consensus” results of other analysts come up with different projections. Based on six climate models assuming a 4.4 degree C rise in temperature and a 2.9% rise in precipitation by the 2080s, it is projected that global agricultural output will reduce by 3.2% due to global warming. Similarly, the IPCC(2007b)estimates that approximately 20 to 30 per cent of plant and animal species are likely to be at increased risk of extinction due to rise in temperature. The impact of climate change on global agricultural GDP has been placed at between -1.45% and +2.6% (Fischer et al., 2002).

The impact of climate change on agriculture will vary across different regions as warming is expected to add 7.7% to agricultural output in industrial countries while reducing output by 9.1% in developing countries. In Africa, it is projected that by 2020 between 75 and 250 million people will be exposed to increased water stress. Also, agricultural production and access to food in many countries will be compromised (reduced by up to 50% in some instances) due to the impact

of climate change on rain-fed agriculture. By 2080, it is projected that there would an increase of 5 to 8% of arid and semi-arid land in Africa.

	Per cent increase with CO2 fertilization
Global	-3.2
Output-weighted	7.7
Industrial countries	
Developing countries	-9.1
Africa	-16.6
Asia	-7.2
Middle East N. Africa	-9.4
Latin America	-12.9

Table 35: Summary estimates of impact of global warming on world and regional agricultural output potential by 2080s
Source: (Cline, 2007, p. 96)

Similarly, climate change (coupled with increased population growth and urbanization) will impact on water availability which will consequently affect agriculture. The largest users of fresh water in the world are farmers. Agriculture accounts for around 86 per cent of global freshwater use mainly through rainfall utilisation, surface water diversion and the pumping of groundwater. Irrigated agriculture provides 40 per cent of global freshwater use (Khan and Hanjra, 2009). Other issues related to global water use is the displacement of millions of people due to expansion of irrigation systems and the associated environmental problems – destruction of wetlands and aquatic ecosystem, water-logging, salinization and contamination of water sources (Molle et al., 2008). However, agriculture faces growing competition from rapidly expanding urban areas. The implication of this is that farmers would have to rely on less water in the quest to double food production to meet growing food needs (Thompson, 2008). Water scarcity has also raised questions of equity in distribution and access especially by the poor. The notion of ‘water footprint’ (i.e. the volume of water required per capita to sustain a population) has been used to show the disparity in water access (with the biggest users being the US and the Mediterranean countries of Southern Europe while most African countries have little or no external water footprints) and the potential problems in regions with limited water resources (Hoekstra and Chapagain, 2007).

The production of biofuels has also significantly affected global agriculture and food production. Biofuels production has pulled land out of other crops by creating demand for corn and edible oils. In some countries like the US, it has reduced the profitability of livestock and poultry industries due to higher feed grains prices. In 2000, the US produced about 1.7 billion gallons of

ethanol (6% of the corn harvest). However, by 2007, the US produced 5.8 billion gallons of ethanol (20% of corn harvest which is now larger than exports). It is projected that by 2008-09, US ethanol production capacity will be 13.4 billion. The Energy Bill of 2007 mandated 36 billion gallons of biofuels by 2022, of which 15 billion will come from corn (Thompson, 2008).

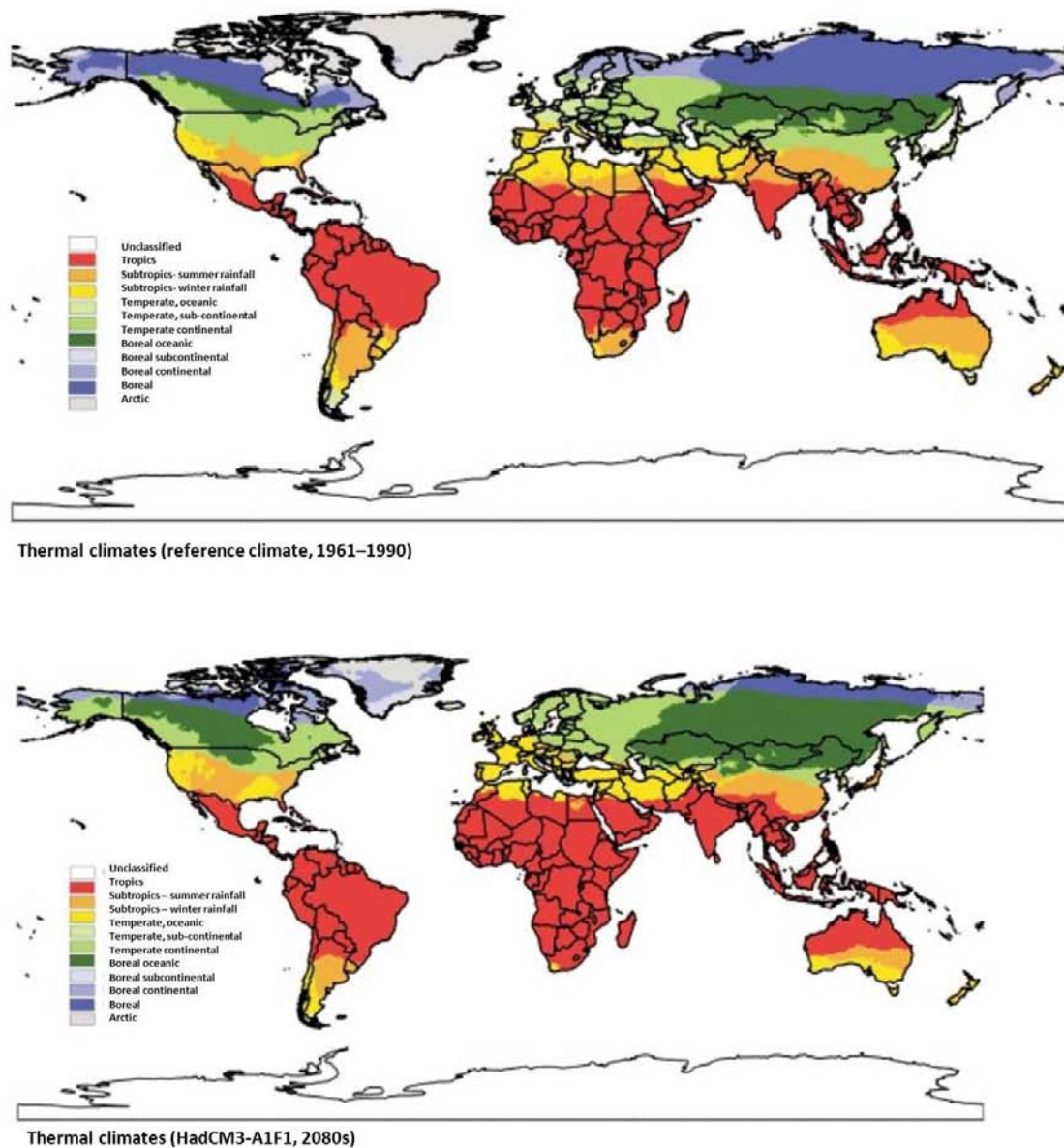


Figure 24: Thermal climates over time
Source: (Fischer, 2002)

Conventional agriculture is, however, both a victim of and a perpetrator of global warming especially through greenhouse gas emission. The contribution of agriculture to climate change varies from region to region and some have argued it is not generally very significant. The IPCC (2007a) estimates that in 2005, the net contribution of global agriculture to GHG emissions is between 5.1 -6.1 GtCO₂-eq/yr. 3.3 GtCO₂-eq/yr (mainly methane from livestock related

production and the decomposition of organic material in oxygen deprived conditions). Nitrogen oxide emissions, mainly from microbial transformations of soil based nitrogen and excessive fertilizer use, was put at 2.8 GtCO₂-eq/yr. Together, these accounted for 10-20 per cent of total anthropogenic GHG emissions.

An important component of the global food system is its dependence on the cheap exploitation of non-renewable energy sources (fossil fuel) at different levels. At production stages, energy consumption by farm machineries such as tractors and planters is very high. Similarly, a high amount of energy is consumed in the making of fertilizers and pesticides (Smil, 2000; Tudge, 2003). The process of post-production in conventional agriculture (processing, packaging and storage) equally consumes energy. Furthermore, more energy is consumed in transporting food items over thousands of miles (i.e. food miles) from points of production to areas of consumption. There is increasing evidence that since 1981, 'peak oil' situation has been reached as close to half of the geological endowment of conventional oil and natural gas has been exhausted. The gap between discovery and consumption is widening and in 2007, it is estimated that the world consumed six barrels for every one that was discovered. This equals 84 million barrels per day, or 30 billion barrels per year (Leggett, 2005).

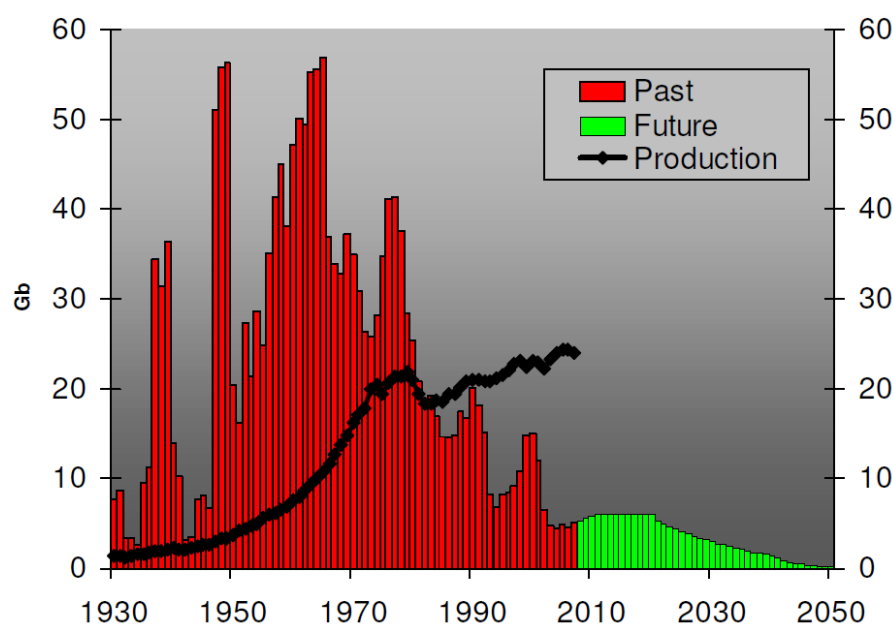


Figure 25: World oil discovery and production
Source: (Sage, 2009)

Also, the earth's ecological capacity to regenerate is said to be severely stretched. The total amount of biologically productive land and water area that a population requires to produce what it consumes and the waste it generates is described using the concept of Ecological Footprint (EF) (Rees, 1992; 1996; Wackernagel and Rees, 1996). It is measured using a standardized area unit

termed a ‘global hectare’ and is usually expressed on a per capita basis (gha/cap). Biocapacity on the other hand tracks the planet’s biologically productive capacity. “By 2001, humanity required 2.2 global hectares of productive area per person to sustain current lifestyles, 1.3 times more than in 1961. But the earth currently has just 1.8 global hectares available per person. This overshoot of some 21 per cent depletes the earth’s natural capital, and is thus possible only for a limited period”(Global Footprint Network, 2005).The worst culprits are countries in North America and Europe. For instance, EU-25’s ecological footprint equals 4.9 globally average hectares per person (gha/cap) to provide for their lifestyle which is 2.2 times as large as its own biological capacity (Wiedmann et al., 2006).

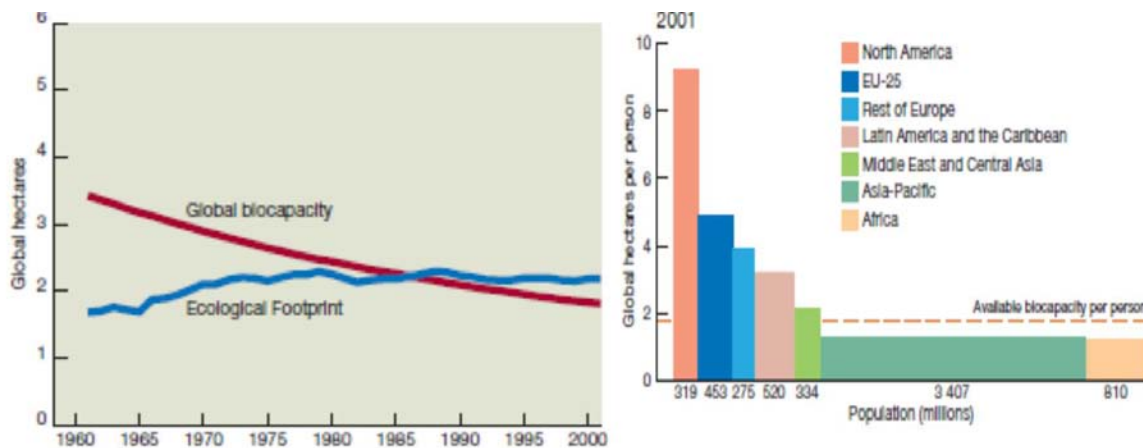


Figure 26: Humanity’s ecological footprint and biocapacity per person (1961-2001) and ecological footprint by region
Source: (Global Footprint Network, 2005)

Generally, agriculture and transportation are among the single biggest contributors to the world’s footprint. Modern agriculture’s EF has increased steadily and is exacerbated by factors such as soil erosion, water shortages and nutrient loading among others (fig 27). With the UN estimating that food production will have to double by 2050 to meet projected population growth and improving diets, it is clear that the remaining hectares of cropland per capita cannot meet this demand (Pimentel and Pimentel, 1996).

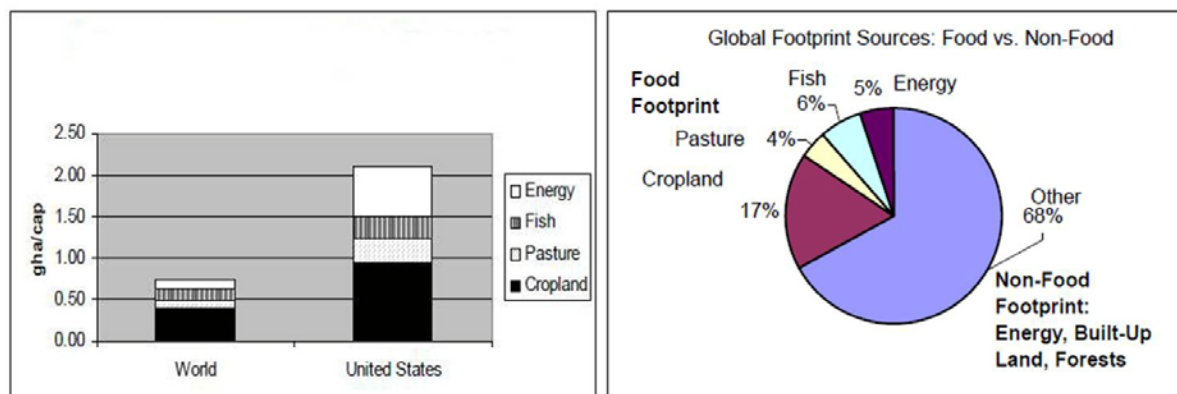


Figure 27: Food footprints of the world and the US with global footprint sources
Source: (Millstone and Lang, 2003)

7.4.3 Conventional Agriculture and the Environment

One of the grave concerns with conventional agri-food production is its negative impacts on the environment through greater mechanization, standardization (including production techniques, varieties and breeds and monocultural production), rising inputs of fossil energy, fertilizers, pesticides and GMO (Byrne et al., 2006). The key premises underlining conventional agriculture are: the problems of agricultural production are pests and diseases, poor soil fertility, water shortages/inefficiency and labour. To solve these problems, conventional agriculture has relied on the use of pesticides and other agrochemicals, construction of irrigation systems, mechanization and genetic modification. Underlying these assumptions is a linear conception of agriculture where success is measured by net output (Horrigan et al., 2002). Agriculture, therefore, becomes synonymous with the industry based on 'inputs' and maximization of 'output'. As a result, the diversity that characterized traditional agriculture is replaced with monoculture. Also, the cyclical outlook of traditional agriculture, where production depends on natural cycles in the ecosystem, is similarly abandoned for the linear approach described above.

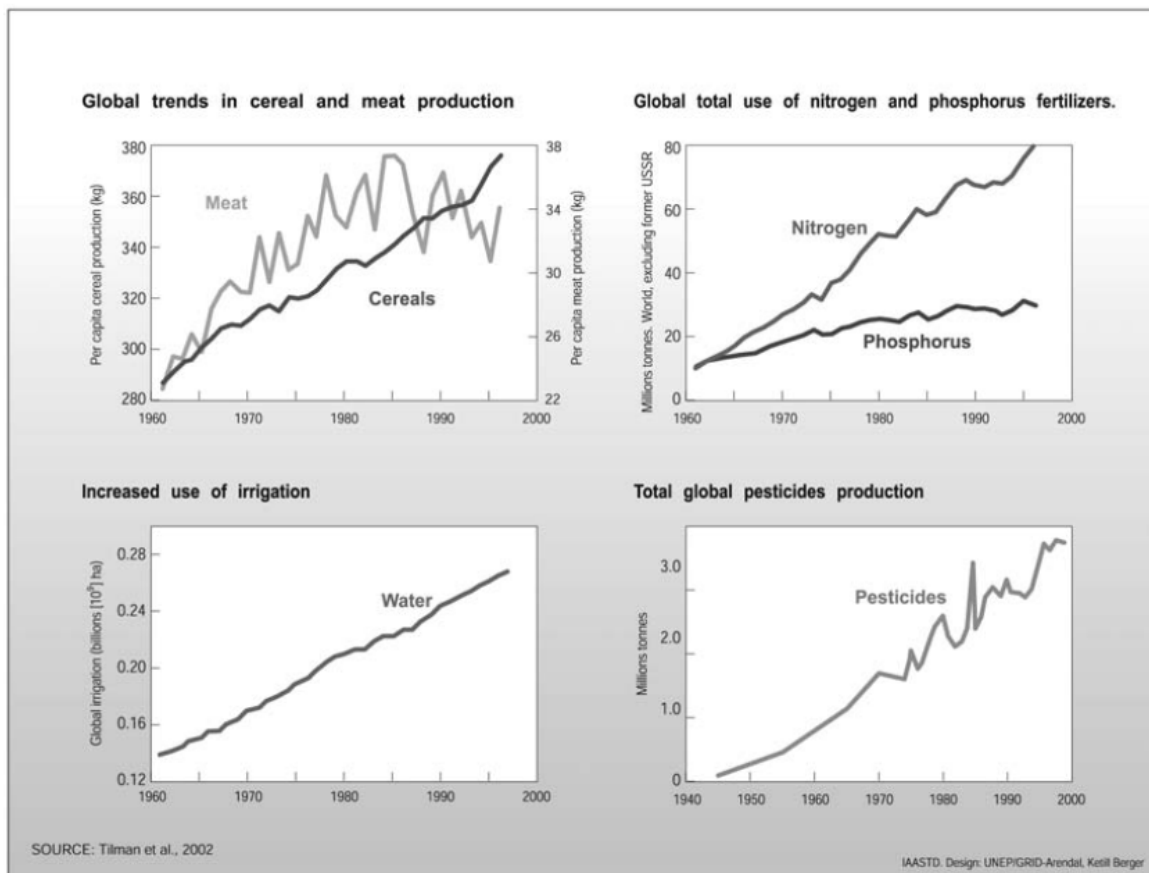


Figure 28: Global trends in cereal and meat production; nitrogen and phosphorus fertilizer use; irrigation, and pesticide production
Source: (IAASTD, 2009)

Current trends (soil dissipation, shortage of fossil energy, environmental issues associated with fossil energy and population increase), have cast doubt over the ability of the current food regime to sustainably meet the high quality diet needs of the world's population. In addition to its heavy reliance on non-renewable energy, the global food economy is dependent on agricultural mechanization which creates or aggravates other problems such as soil erosion mainly through activities such as farm expansion, cultivation of marginal lands, excessive cultivation, overgrazing and use of machines. Similarly, overgrazing puts more strain on the land and exposes it to erosive agents. In addition, conventional agriculture's reliance on massive irrigation schemes and dam construction results in water depletion, degradation of aquatic ecosystems, reduction of water quality and mismanagement. This problem is more severe in the case of underground water (aquifers) whose recharge rates are usually very slow. Oversubscription of underground water or its depletion increases the cost of harvest, and in coastal areas, it may create problems of salinity. The natural rate of salinization is often increased due to the accumulation of salt in the soil as a result of irrigation. Ultimately, high salinity affects the rate of water uptake and circulation in plants.

Fertilizers have contributed in increasing crop yields and reducing prices of food items in many parts of the world, especially in developing countries. However, these gains often come at a price not always explicitly stated or accepted by proponents of fertilizer use. Excessive use of fertilizer results in short term and long term harmful effects on the soil, water and inevitably, human health (Gliessman, 1998). Fertilizers seriously impact on soil microbes such as nitrogen fixing organisms and others that help improve soil structure through their activities (Magdoff and van Es, 2000). Secondly, too much fertilizer can lead to water pollution through leaching as fertilizers are generally highly soluble in water. Most of the fertilizer applied on farms run-off into streams and water bodies and thus pollute both surface and underground and endanger aquatic life (Carpenter et al., 1998). Furthermore, surplus fertilizer (especially ammonia) can lead to volatilization, whereby dissolved ammonia is converted to ammonia gas (Jones et al., 2007). This process is usually enhanced by such factors as rain or irrigation (Cabrera and Vervoort, 1998), soil properties such as pH, moisture and temperature (Al-Kanani et al., 1991), and hydrogen buffering capacity (Ferguson et al., 1984). Nitrates from fertilizers are harmful to human health when ingested and can affect the liver and kidney and lead to miscarriages. Besides, that so much fertilizer is actually lost through leaching means waste of money especially for farmers who can scarcely afford it in the first instance.

The unintended harmful impact of pesticide use on the environment is equally well researched. Only about 0.1 per cent of applied pesticide actually reaches the target pest (Silver and Riley, 2001). The rest that is unused ends up as environment contaminants through one or more of the following ways: drift, volatilization, leaching and run-off. Despite this, pesticide use per year has increased significantly in the last 50 years from 50 million kg in 1945 to 2.5 billion kg in 1995 with an estimated annual cost of \$100 billion (Pimental, 1997). With increased productivity has come increased environmental and health risks. The extent to which pesticides affect the soil is determined by three main factors: mobility, i.e. pesticide movement in the soil; the amount of time it takes for half of the applied pesticide to break down (half-life) and; the length of time it takes before all residue of the pesticide completely disappears (table 36) (Silver and Riley, 2001).

Pesticide	Product Names	Half-life	Persistence	Other
Glyphosate	Roundup	3 - 141 days	Varies widely: 55 days - 3 years	Initial degradation is faster than subsequent degradation of what remains. The U.S. Environmental Protection Agency (EPA) states that glyphosate is "extremely persistent under typical application conditions"
Dichlobenil	Casoron Norosac Barrier	Varies widely: 16 - 241 days	> 5 years	Highly volatile. Residues sufficient to damage crops have been found 2-5 years after soil application. One study found that 42-57% of dichlobenil remained 105 days (3.5 months) after treatment to soils
Clopyralid	Confront Transline Stinger	up to 11 months	2 - 14 months	Considered "persistent" and "volatile."
Triclopyr	Confront Garlon	75 - 81 days 2 - 8 weeks	Varies widely: 1 month - 2 years	The primary breakdown product (degradate) of triclopyr is 3,5,6-TCP. This chemical is comparable in toxicity to triclopyr itself, and has been found in triclopyr-treated soil for more than 63 weeks.
Oryzalin	Surflan	> 60 days	> 3 years	EPA states: "Chronic post-application exposure from residential lawn applications is of concern because oryzalin is a possible human carcinogen and persistent. There is a potential for continued, substantial contact with treated surfaces, particularly among children. There are no data to evaluate potential exposure to turfgrass and therefore the safety of this use cannot be evaluated"

Table 36: Half-life and persistence in soil of active ingredients of some common weed killers
Source: (Silver and Riley, 2001)

Pesticides affect beneficial soil microbes that help in natural nutrient cycle and can reduce soil organic matter, soil pH and moisture content, and initial infiltration rate (Clements et al., 1991). Also, herbicide use has resulted in reverse effects such as increased resistance in weeds and insects (table 37). Within the last 50 years, over 183 plant species across six continents have been known to develop resistance to herbicides either by altering herbicide target enzyme, enhancing herbicide metabolism or reducing herbicide translocation (Heap, 2007; Neve, 2007). This is the case with the most popular types such as glyphosate which are still widely used in many developing countries.

Increased weed resistance often means more use of pesticides which are ultimately underutilized and leached into water bodies.

Herbicide	Year of Resistance Found	Year of Reporting
2,4-D	1945	1963
Dalapon	1953	1962
Atrazine	1958	1988
Picloram	1963	1973
Trifluralin	1963	1982
Diclofop	1977	1982
Triallate	1962	1987
Chlorsulfuron	1982	1987
Glyphosate	2003	2006

Table 37: Worldwide herbicide resistance against widely used types of herbicide groups
Source: (Le Baron, 1991; Valverde and Greessel, 2006)

Thirdly, when in water (surface or underground), pesticides have varying negative effects on aquatic life such as fish. Furthermore, due to their affinity to water, pesticides adversely affect wildlife (e.g. the grey partridge, farmland birds) and wild life habitat mainly through processes such as agricultural expansion and intensification, drift and over-spraying (figure 29). Additionally, pesticides (e.g. DDT, endosulfan, and toxaphene) often end up in food and water thereby directly increasing risks to health (LeBlanc et al., 1997; Cole et al., 2000; Crissman et al., 2000; Sherwood et al., 2005).

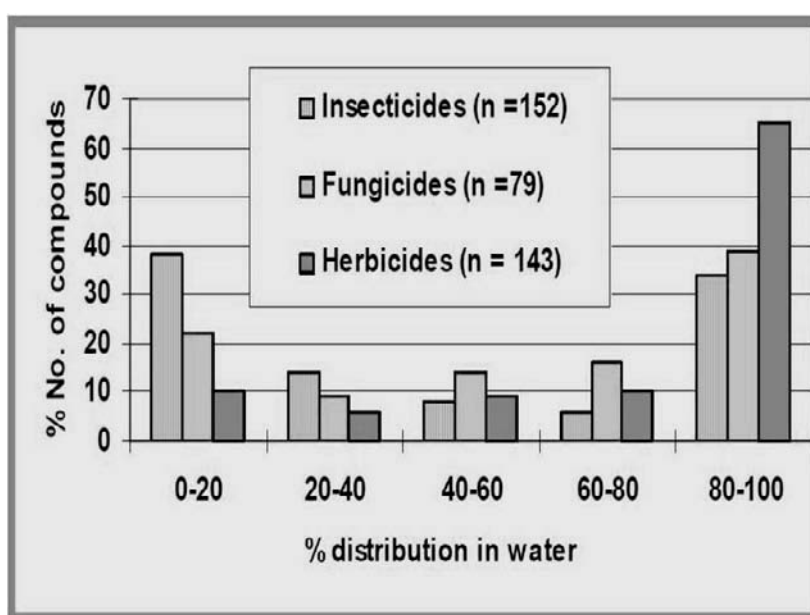


Figure 29: Affinity of pesticides to water based on fugacity modelling
Source: (Funari et al., 1995)

Also, huge amounts of money are annually spent by governments in Europe and the Americas to purify water of pesticides and make food safe for consumption. These high costs undermine the efficiency of conventional agriculture as the costs of the activities of these industries is not 'internalized' rather, as shown above, they are displaced ('externalized') onto the public through various forms of pollution. When the combined effects of these externalities (on human health, biodiversity, environmental quality, loss of community) are taken into account, it becomes clear that conventional agriculture and the current global food system result in more harm than good through the pursuit of easy productivity and profit (Beckenbach, 1994; Faber, 1998; Martínez-Alier, 2002; Pretty, 2005; Tegtmeyer and Duffy, 2005).

Conventional agriculture also has important implications for biodiversity. Thrupp (2000) identifies the components of agricultural biodiversity as encompassing the following: genetic resources which are the essential living materials of plants and animals; edible plants and crops which include traditional varieties, cultivars, hybrids and other genetic material developed by breeders; livestock and freshwater fish; soil organisms vital to soil fertility, structure, quality and health; naturally occurring insects, bacteria and fungi that control insect pests and diseases of domesticated plants and animals; agroecosystem components and types (polycultural/monocultural, small-/large-scale, rain-fed/irrigated, etc.) indispensable for nutrient cycling, stability and productivity; and 'wild' resources (species and other elements) of natural habitats and landscapes that can provide ecosystem functions and services. In addition to these, agrobiodiversity includes the ways in which farmers take advantage of biological diversity in the production and management of crops, land, water, insects and biota (Brookfield and Padoch, 1994; Thrupp, 2000).

Crop specialization (uniformity and monoculture), whereby single crops are grown on much of the land, erodes biodiversity which plays an important role in agricultural production and food security and environmental conservation (Francis, 1986; Vandermeer, 1989; Altieri and Farrell, 1995; Altieri, 1994; Gliessman, 1998). Ironically, traditional societies have, for millennia, understood and exploited biodiversity maintenance in their practice of agriculture. Examples include small-scale polycultural systems, traditional agroforestry, and use of geographically and ecologically distinctive 'folk varieties' which are conspicuously diverse in their genetic composition (Thrupp, 2000).

Loss in biodiversity, through degradation as a result of conventional agriculture, has immediate and severe consequences on food security. For instance, loss in genetic diversity undermines the stability of agriculture and increases vulnerability to climatic and other stresses. "Although people consume approximately 7,000 species of plants, only 150 species are commercially important, and about 103 species account for 90 per cent of the world's food crops – rice, wheat, and maize –

account for about 60 per cent of the calories and 56 per cent of the protein people derive from plants” (Thrupp, 2000, p. 269). In many parts of the world, traditional nutritious crop varieties are threatened with extinction because of modern crop and high yielding varieties. For instance, in Senegal the traditional nutritious cereal fonio (*Panicum laetum*) is under threat (Mann, 1990; IFOAM, 1994, p. 5). The extent of genetic uniformity in certain key crops is summarized below (table 38). Similar loss in livestock diversity has resulted in the disappearance of traditional strains which are instead replaced by new breeds of cattle, pigs, sheep and chickens. According to the FAO, every week at least one traditional breed of livestock is lost in the world (Plucknett and Home, 1992).

Crop	Country	Number of Varieties
Rice	Sri Lanka	From 2,000 in 1959 to fewer than 100 today; 75% descend from a common stock
Rice	Bangladesh	62% of varieties descend from a common stock
Rice	Indonesia	74% of varieties descend from a common stock
Wheat	United States	50% of crop in 9 varieties
Potatoes	United States	75% of crop in 4 varieties
Soybeans	United States	50% of crop in 6 varieties

Table 38: Extent of genetic uniformity in selected crops
Source: (World Conservation Monitoring Centre, 1992)

Genetic uniformity often results in increased vulnerability to pests and diseases as has been evidenced many times in history. The direct fallout of this is crop failure and food insecurity (table 39). Recently, there was the case of the devastating mould that infested hybrid maize in Zambia.

Date	Location	Crops	Effects
1846	Ireland	Potato	Famine
1800s	Sri Lanka	Coffee	Farms destroyed
1940s	United States	Various	Crop loss to insects doubled
1943	India	Rice	Famine
1960s	United States	Wheat	Rust epidemic
1970	United States	Maize	US\$ 1 billion loss
1970	Philippines Indonesia	Rice	Tungo epidemic virus
1974	Indonesia	Rice	3 million tons destroyed
1984	Florida, US	Citrus Fruits	18 million trees destroyed

Table 39: Past crop failures due to genetic uniformity
Source: (World Conservation Monitoring Centre, 1992)

In addition to the above, Thrupp identifies other biodiversity losses resulting from the use of agrochemicals. One of such is the decline in soil organisms (insects and fungi) and soil nutrients leading to loss in productivity because these organisms play an important role in the natural process and balance of the ecosystem (2000, p. 272). Other equally distressing effects of biodiversity losses as a result of uniformity (i.e. the dominance of monocultural models) and agricultural expansion include the loss of farming systems, habitats, nutrition, and cultural diversity/knowledge. Natural habitats, including tropical forests, grasslands and wetlands are lost through land conversion, the ecosystem is disrupted, nutrition affected through the introduction of 'modern' monoculture cereals and valuable traditional knowledge is lost through uniform industrial agricultural technologies (Altieri and Farrell, 1995).

7.4.4 Markets, Policy and International Trade

Agriculture plays an important and multifaceted role in national economies, especially in developing countries whose economies are mostly based on agriculture. Agriculture's role in the economy relates to the following: trade, foreign exchange, aid and investment, international prices of agricultural commodities and inputs, and production and consumption patterns (Fischer et al., 2002). The importance of agriculture to the economy of developing countries is reflected in its share in the gross domestic product (GDP) of these countries – 13% in contrast to the 2% in developed countries. This share is over 31% for sub-Saharan Africa, 25% for South Asia (Fischer et al., 2002). This dependence on agriculture makes developing countries economically vulnerable.

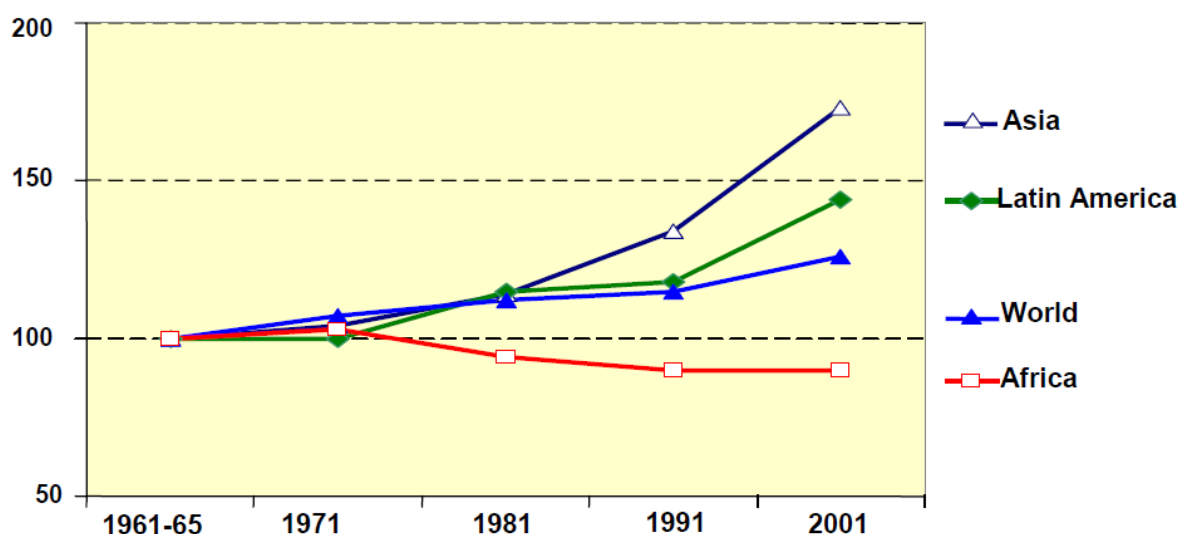


Figure 30: Regional differences in the development of agricultural production/capita
Source: (Southgate et al., 2007)

Despite the increase in the average growth rate of the GDP in developing countries in the 1990s, there was marked overall decline in production/capital of all major food crops and whatever marginal growth was experienced in some countries was further eroded by high population growth, thus widening the gap in the standard of living between Africa and other regions (fig 30). The estimated “consumption expenditure of the average African household is one-fifth lower than it was a quarter of a century ago. In all, the richest 20% of the world’s population consumes 85% of the world’s income, while the poorest 20% lives on about 1% of global income” (Fischer et al., 2002). This trend has clearly increased as the richest 20% in the world are now 70 times richer than the poorest 20%. Despite same international prices for all countries, the income terms of trade for agriculture (purchasing power of agricultural exports) have evolved differently for developed, developing and least developed countries with the last two being the worse hit (fig 31). Throughout the 1980s and 1990s, African countries involved in the export of traditional agri-commodities experienced steep decline in the relative exchange value of their exports compared to developed countries. For example, according to Weis (2007), the internationally traded price of tea had fallen to 47% of its 1980 value by 2002, groundnuts to 38%, palm oil to 24%, cotton to 21%, cocoa to 19% and coffee to just 14%.

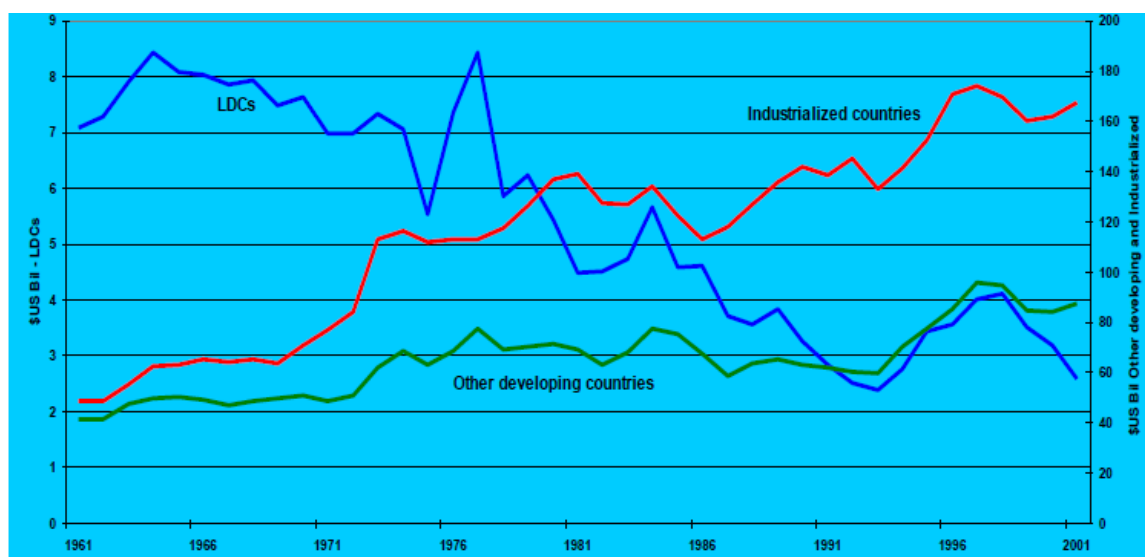


Figure 31: Income terms of trade for agriculture
Source: (Sarris, 2007)

On the other hand, there has been a decline (from \$58 billion in 1992 to \$53 in 2000) in Overseas Development Assistance (ODA) to developing countries and few countries meet their aid targets of GDP (fig 32). This decline is more evident in Africa where some countries suffered a decline of between 25% and 50%. Even though the share of ODA going to low-income

countries has remained roughly constant, ODA to agriculture, which contributes to the livelihoods of people in these countries, declined from 20% in the late 1980s to about 12% in 2000.

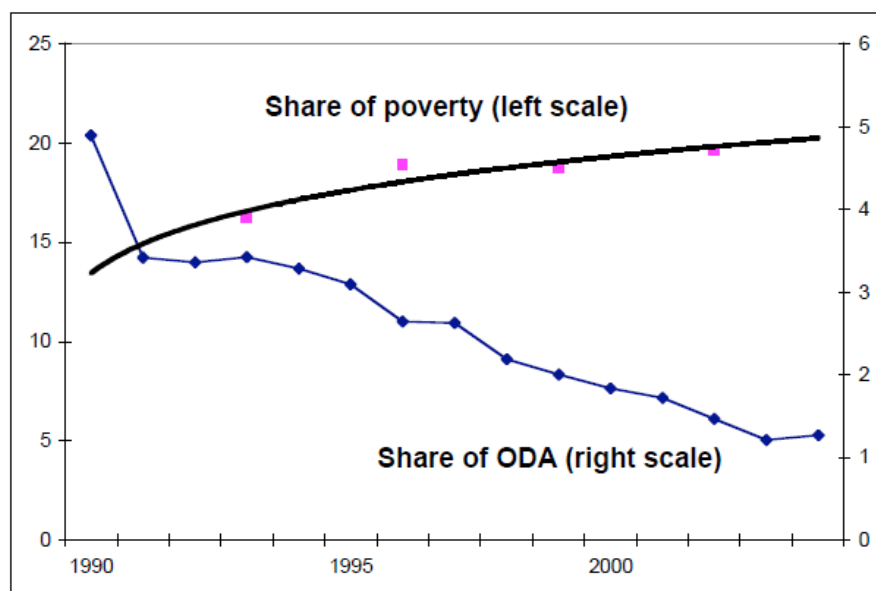


Figure 32: Share of African rural poverty in world poverty and share of world ODA to African agriculture
Source: (Ravallion et al., 2007)

Many high income countries (particularly OECD countries), where most of the ODA originates, subsidize their agriculture (\$350 billion annually) thereby distorting relative returns to producing various outputs and inducing larger total investment in agriculture relative to other sectors (table 40). By maintaining agriculture in the OECD countries through import barriers and export subsidies, agricultural production in poorer countries is discouraged and their foreign exchange earning capacity is reduced (Fischer et al., 2001). Poorer countries, unlike developed countries, do not have the financial means to subsidize their farmers resulting in low income. Africa's share of world exports has declined from 2.7% in 1990 to 2.1% in 2000 despite the international trade booms of the 1990s when world exports grew at a rate of 6.4%.

Rice	75
Sugar	58
Milk	36
Beef & Veal	34
Wheat	33
Corn	31
Oilseeds	27
Pork	21
Overall	30

Average Producer Support* in OECD Countries, 2004, in Percent

Rice	33-50%
Sugar	20-40%
Dairy Products	20-40%
Cotton	10-20%
Peanuts	10-20%

World Market Prices Depressed Below Long Term Trend

Table 40: *Percent of gross farm receipts attributable to all forms of government subsidies, support and protection from imports.

Source: (OECD, qtd. in Thompson, 2008)

Developing countries are yet to benefit from the promises of free trade as pledged by the World Trade Organization (WTO). OECD agricultural production and export subsidies depress world market prices below long-term trend and increases variance around that trend (Thompson, 2008). Also, much of Africa continues to depend on traditional bulk agricultural commodities for a major share of its export. There has been a steady decline in real prices of agricultural commodities on world markets since the 1990s. The total food imports in developing countries amounted to only \$60 billion in 2000. The contribution of agricultural products in the total exports of some 53 developing countries is little less than one-fifth and these countries spend more of their total export earnings on food imports. Paradoxically, African countries have been losing market share to other developing countries even in exports of certain basic commodities and the export performance and overall trade balance in African countries have declined following trade liberalization.

An important factor that affects patterns of food demand and global trade is the differences in what food products countries want and accept. Such demands for quality have the potential to complicate trade rules and also lead to increased production costs. They can also lead to disputes between trading partners as when domestic producers protest policies and regulations imposed on them but not on foreign producers. Through greater multilateral coordination among producers, they are better able to harmonize standards and rules to facilitate global agricultural trade.

In summary, domestic agricultural and trade policies distort special patterns of production of different commodities both within and among countries. Also, subsidies and protectionism in developed countries increase the cost of food, reduce agricultural production efficiency, redistribute income and wealth to the largest farmers and land owners and hurt poor farmers in low income countries (Thompson, 2008).

7.5 Agriculture at Crossroads – Beyond Business as Usual

What emerges from the consideration of the global food economy above is that the growing demand for food for an increasing population in a time of severe biophysical limitations is threatening natural resources as people strive to get the most out of land already in production. The result includes the following damages: arable land lost to erosion, salinity, desertification and urban spread, water shortages, disappearing forests and threats to biodiversity. This has been revealed have dire consequences on smallholders in developing countries. Findings by the International Assessment of Agriculture Science and Technology for Development (IAASTD) recognize the complexities of the problems facing agriculture throughout the world and show that if the current global food system is to deliver wholesome, safe and affordable food without causing long-term harm to the environment in the future, it needs to be overhauled (IAASTD, 2009). The report identifies the current conditions that shape the global food system, the challenges and options available for a more tenable system. Agricultural Knowledge, Science and Technology (AKST), the report says, have undoubtedly contributed to substantial increase in agricultural production over time, contributing to food security. However, this has come with some unacceptable social and environmental consequences. The problems faced by the global food system have been exacerbated by: the uneven distribution of AKST benefits due to institutional and policy pitfalls and changing population and income patterns which will exert more pressure on food supply. Given these consequences and mounting crisis in food security, the report argues that business as usual is no longer an option.

...despite significant scientific and technological achievements in our ability to increase agricultural productivity, we have been less attentive to some of the unintended social and environmental consequences of our achievements. We are now in a good position to reflect on these consequences and to outline various policy options to meet the challenges ahead, perhaps best characterised as the need for food and livelihood security under increasingly constrained environmental conditions...' (IAASTD, Executive Summary pp.3)

The report acknowledges the multifunctionality of agriculture, i.e. its role in providing services other than just food, fibre, raw materials and biofuels production, for instance ecosystem

services, landscape and cultures. It calls for AKST to be redirected to agroecology so as to address environmental issues and pervasive and persistent economic inequities. Also, AKST needs to be redirected to utilize: women's knowledge, skills and experience, formal, traditional and community-based science and technology and other similar alternative methods of resource management. While supporting the development and application of new and emerging AKST, the report calls for increased public research investment in smallholder agriculture. Such a pro-poor approach will reward sustainable smallholders as well create opportunities for innovation and entrepreneurship for them. These changes can only be brought about within the framework of a new system of governance and international agreements that address the bias towards short-term considerations for productivity over environmental and social sustainability and the multiple needs of smallholder farmers. The report argues that this new system should strive to: adopt ecologically and socially sustainable agricultural systems, address the problem of poor access to credit, land/water and the unfair trade terms that confront smallholders, increase AKST investment taking into account agricultural multifunctionality, recognize diverse perspectives and the multiplicity of scientifically well-founded options, reduce the risks associated with intensive export-oriented agriculture under open market (exportation of soil nutrients, unsustainable soil and water management and exploitative labour conditions).

Some have criticized the IAASTD report for its view on agricultural markets and the role of new technology which the report implies to be part of the problem and not part of the solution (Stokstad, 2008). It is accused of ignoring the input of experts in biotechnology and molecular biology and the potential of the private sector to contribute to global public good character of sustainable agriculture and food security. Also, despite its valuable insights on the problems of agriculture, some say the report is still largely based on the erroneous assumption that hunger is largely a problem of distribution. Thus, it fails to address the challenge of producing more food with less land and water (Aerni, 2008). Others have questioned its timing, observing that its impact would have been greater were it linked to the WDR 2008/2009 with which it overlapped. Equally, some argue that "the AKST sector would have gained much from the IAASTD process if it had made an explicit scrutiny of the institutions and processes that are responsible for guarding and enhancing the relevance and quality of AKST for sustainable development and poverty alleviation" (Kassam, 2010).

These notwithstanding, the IAASTD report has made a significant major step in reshaping the future of agriculture in a way that is productive and sustainable. Its strength, in my view, lies in its acknowledgement of the key role that smallholders and indigenous knowledge should play in

developing appropriate technologies and systems for the future. Another of its strengths is the recognition that meeting the challenges facing agriculture over the next 50 years will require more integrated applications of existing science and technology (formal, traditional and community-based), as well as new approaches for agricultural and natural resource management. Equally important is the emphasis that AKST needs to be systematically redirected towards agroecological strategies that address environmental issues. The long-term value of the IAASTD process will depend on how many of the key findings are retained and strengthened.

In formulating alternatives to conventional agriculture, therefore, there must be a greater role for grassroots actors such as smallholders in decision making instead of the traditional non-placed-based powerful actors (states, large businesses and institutions of global governance) (Dryzek, 1987; Norgaard, 1994). Similarly, considerations of social justice and environmental conservation should inspire the decision making process (Chambers, 1987; Hecht and Cockburn, 1992). The challenge is not just to increase production but more importantly to do so with due ecological and social considerations (Fernandes et al., 2005, p. 322). Hence, farming systems need to be considered holistically instead of just striving to improve single components like land use or labour supply. This can be done by looking at the field dimensions of agriculture such as crop cycles and studying how harmonious and symbiotic relationship obtains in nature (Mollison, 1990). Also, when considering the spatial dimensions of agriculture, it will be helpful to move away from the *two dimension* view of agriculture, i.e. as ‘an activity carried out on a plane’ to a *three dimensional* view (i.e. spatial dimension of agriculture where soil is thought of as volume instead of surface) (Fernandes et al., 2005, p. 326). Agriculture’s *multifunctionality* and its non-food functions are as important as its food functions and these two need to be balanced in such a way that the positive effects of agriculture are improved and its negative effects reduced (Pretty, 2005, p. 54). Worster (1993) has suggested three principles of good farming that could help in achieving this balance: farming that makes people healthier, farming that promotes more just society, and farming that preserves the earth and its networks of life.

7.6 Developing a Conceptual Framework for Achieving a Sustainable Food System

As shown above, solving the food crisis and ensuring long-term food security requires a close examination of the structural causes of the problem. This must go beyond piecemeal measures such as more aid, free trade, GRs and more subsidies to embrace a radical and innovative reform of the whole system by promoting productive, equitable and sustainable alternatives that rely more on nature’s own functionings, supporting sustainable and agro-ecological agricultural farming practices, reprioritize indigenous knowledge systems and technical practices as a way of reducing

the influence of agribusiness, empowering and protecting the rights of smallholder farmers in areas such as trade, access to extension, technical assistance and the market, re-investing in food production and commodities, researching more and controlling the use of food for fuel. Such measures will help bridge the gap between actual and potential smallholder productivity, reduce poverty, increase food production and help the environment (Fairtrade Foundation, 2009).

The quest for greater food security must be balanced with the demands of protecting the environment. Conventional agriculture's solution to the challenge of meeting global food needs is neither tenable nor sustainable. With its focus on high external input and monoculture, conventional agriculture negates the relationship that should exist between the soil, crops and animals, ignores the natural cycles of nutrient, water and energy, increases the tendency and susceptibility of agroecosystems to pests by reducing the effectiveness of natural predators, increases the need for chemical control and erodes crop variety and biodiversity (Altieri, 2000).

Alternatives to conventional agriculture generally promote measures aimed at increasing productivity while at the same time maintaining sustainability. Features of these alternatives include: a more thorough incorporation of natural processes such as nutrient cycles, nitrogen fixation, pest-predator relationships into the agricultural process, reduction in the use of off-farm inputs with the greatest potential to harm the environment or the health of farmers and consumers, improvement of the match between cropping pattern and the productive potential and physical limitations of agricultural lands to ensure long-term sustainability of current production levels and the promotion of profitable and efficient production with emphasis on improved farm management and conservation of soil, water, energy and biological resources (Gliessman, 2001; Kimbrell, 2002).

At the core of most alternative models is smallholder agriculture which is the main source of livelihood of billions of people in the rural areas around the world. Increasing the production potential of these smallholders is one of the surest and the quickest way of ending poverty and ensuring sustainable rural development. However, the need for increased productivity of smallholder farmers should be balanced with the concern for sustainability, i.e. ensuring food security and ecological stability.

If, in an obsession with increasing productivity, we were to fail to address the fundamental issues raised above, or even marginalise them still further, then we risk actually making things worse. On the contrary, we must focus on rehabilitating all favourable elements inherent in different agricultural systems, with the central aim of building the resilience of socio-agricultural systems in

the face of shocks (whether these be climatic, or shocks in the international finance system). It is in this context that we must look to a conceptual framework which fulfils the following criteria: (a) treats agriculture for what it is, i.e. part of natural systems which circulate nutrients, water etc. and (b) treats the physical productive and social systems as interrelated. These issues are addressed in several complementary approaches to 'alternative agriculture' shown above, and it is my contention that agroecology does this most completely.

This is because agroecology is a multi-dimensional, multi-disciplinary approach that is pro-poor and pro-environment. It builds on the knowledge and experience of smallholder farmers and is also grounded on a sound understanding of agroecosystems and the principles by which they function. By taking into account the agricultural systems of indigenous people who have been sidelined by conventional agriculture, agroecology repositions smallholders at the forefront of the quest to achieving food security, especially in developing countries. Thus, agroecology effectively achieves the four-pronged objectives of: poverty alleviation, food security and self-reliance, ecological management of productive resources and empowerment of rural communities (Altieri, 2002, p. 2). It is the contention of this thesis that findings from this research confirm and refine agroecology showing that it is not just a neat theory, but testable in real situations. As evidenced by findings in Karshi and Baddeggi, smallholders are creative in a dynamic way, combining elements inherent in their traditional systems with inputs typical of conventional agriculture. Findings showed that the systems studied are resilient and creative, both fighting to preserve some of the best aspects of tradition (such as water and soil management) which is crucial especially in the context of climate change and other pressures, while being at the same time lively and developmental, capable of continuous adaptation to critically encompass elements of modern agriculture. But they are also fragile, in some respects clinging on by their finger-tips; there is a risk of this precious socio-productive heritage being lost, and this is where the normative aspect of our conclusions comes in.

7.6.1 Agroecology: A Whole-Systems Approach to Rebuilding the Food System

In light of the serious challenges facing the global food system, its effectiveness to deliver sound nutrition has been questioned (Gliessman, 2001; Kimbrell, 2002). In an increasingly complex, turbulent, unpredictable environment, the vital challenge centres on how to design farming systems that "centre on the peoples' right to exercise control over the resources they need to acquire food and which promote "effective local, national and even international institutions and political systems capable of monitoring and providing for scarcities" (Madeley, 2002, p. 50). The alternative system should target poverty alleviation and food production by empowering the people who need food the most to produce it. To achieve food security means food is "available at all times, to

which all persons have means of access, that is nutritionally adequate in terms of quantity, quality and variety, and is acceptable within the given culture” (Rome Declaration on World Food Security and Plan of Action cited in Madeley, 2002, p. 38). This cannot be achieved unless key questions of “who produces the food, who has access to the technology and knowledge to produce it, and who has the purchasing power to acquire it” are answered (Pretty et al., 2005, p. 375). Sustainable alternative agricultural systems should draw from the best of existing systems and techniques (both formal and informal) so as to reconfigure the meaning of ‘development’ (Williams and Millington, 2004, p. 103). The resulting blend could combine the principles of organic agriculture and traditional agriculture while not completely ignoring the positive input of conventional scientific knowledge. New technologies alone cannot lead to sustainability unless the longer-term, more complex impacts of the entire agricultural system are included in the evaluation. The agricultural system is an important component of the larger food system (Francis et al., 2003).

Agroecology explores the issues surrounding increasing agricultural productivity, ecological soundness and social equity. It is a participatory and multidisciplinary approach to ‘sustainable development’ that takes indigenous models of sustainability and other theories, such as post-development and poststructural theory into account (Escobar, 1995; Gibson-Graham et al., 2001). It embraces any strategy that improves small farm productivity, sustainability and stability. According to Barrett et al. (2002), complementarities should be reinforced instead of the divide between ‘modern’ and ‘agro-ecological’ methods. ‘Real progress can only come from a synthesis of the best of the past, eliminating practices that cause damage to environments and human health, and using the best of knowledge and technologies available to us today’ (Pretty, 2002, p. xiii).

Agroecological research is in sync with many traditional agricultural practices in that it is more diffuse, ‘farm-based’ and participatory. However, it is also considerably based on the conventional experimental/scientific model which aims at universally applicable, context breaking solutions. Significantly, it is also focused upon ‘public goods’, resources and techniques that are not readily patentable but which are, generally, freely available (Parrott and Marsden, 2002). Agroecology reflects the reality of most smallholders in the developing countries who are neither strictly ‘traditional’ nor ‘modern.’ They transcend these categories as evidenced in their ability to utilize elements across both categories.

7.6.2 Agroecology: Principles and Strategies

Increasingly, farming is understood to be part of a much larger system that includes environmental, economic, and social components (Gliessman, 2001; Flora, 2001). Agroecology is a response to the decline in the quality of natural resource base that has resulted from the reckless use of non-

renewable energy resources by conventional agriculture (McIsaac and Edwards, 1994). It seeks to go beyond the one-dimensional view of agroecosystems (their genetics, agronomy, edaphology, and so on) that characterizes conventional agriculture to a more holistic approach that emphasizes the interdependence of the different components of agroecosystem (Vandermeer, 1995).

Agroecological principles have been advocated for since the 1960s and 70s but it was only in the 1980s was it taken seriously, mainly through recognition of the validity and efficiency of traditional agricultural systems. By the 1990s, agroecology had developed a conceptual framework that characterizes a scientific discipline in order to holistically study agroecosystems and develop principles for the design and management of sustainable agriculture and food systems (UNEP, 2005; Gliessman, 2007).

Agroecology is grounded on the notion of ecosystem complementarities as seen in the dynamic, yet steady and sustainable relationship between living organisms and their natural environment over time (Odum, 1997; Gliessman, 1998). Agroecology strives to build its vision of sustainable agriculture on the equilibrium achieved by this natural system. “A well-developed, mature natural ecosystem is relatively stable, self-sustaining, recovers from disturbance, adapts to change, and is able to maintain productivity using energy inputs of solar radiation alone” because it maintains the thin balance between “the complex set of biological, physical, chemical, ecological, and cultural interactions” that obtains in the natural environment (Gliessman, 2001, p. 105). Agroecology studies the interrelationships and processes that obtain in natural ecosystems, including the environmental and human elements, so as to manipulate agroecosystems to improve production in a way that is sustainable and with fewer external inputs (Gliessman, 1998). Gliessman (2005) identifies the four key emergent qualities of ecosystems and how they are altered and converted into agroecosystems. These are: energy flow, nutrient cycling, population regulating mechanism, and dynamic equilibrium. The characteristics and benefits of a natural ecosystem are summarized in the table (41) below:

Property	Natural ecosystem	Modern agroecosystem	Sustainable agroecosystem
Productivity	Medium	High	Medium (possibly high)
Species diversity	High	Low	Medium
Output stability	Medium	Low-medium	High
Biomass accumulation	High	Low	Medium-High
Nutrient recycling	Closed	Open	Semi-closed
Trophic relationships	Complex	Simple	Intermediate
Natural population regulation	High	Low	Medium-High
Resilience	High	Low	Medium
Dependence on external inputs	Low	High	Medium
Human displacement of ecological processes	Low	High	Low-Medium
Sustainability	High	Low	High

Table 41: Characteristics & benefits of natural ecosystems compared with modern & sustainable agroecosystems
Source: (Gliessman, 2005)

Conventional agriculture and agroecosystems, through heavy reliance and use of fossil fuel input, become through-flow systems and energy is not conserved within the system but directed outward. Thus, internal ecosystem processes like nutrient cycling are hampered through biomass loss. In order to maintain the internal balance in ecosystem functions, it is imperative to encourage use of renewable sources of energy. Similarly, conventional agriculture tackles the problem of ‘nutrient leaks’ through the provision of nutrient inputs derived from non-renewable sources like petroleum. This needs to be reversed if sustainability is to be achieved. Instead, recycling mechanisms are needed to replenish soil nutrients lost through exposure. Furthermore, the loss of biodiversity through human directed genetic selection and domestication which simplifies the agroecosystem and leads to more vulnerability should be minimized. Finally, the dynamic equilibrium in mature ecosystems which ensures resilience to most disturbances in the system is often upset through structural and functional uniformity of conventional agriculture. “To reintegrate sustainability, the emergent qualities of system resistance and resiliency must once again play a determining role in agroecosystem design and management” (Gliessman, 2005, pp. 106-107).

Agroecology is based on the application of the following basic principles. First, agroecology is about less use of external inputs in agricultural production as these degrade the environment and in addition to expending scarce resources pose health and other dangers. In place of these costly external inputs, natural processes such as nitrogen-fixation and biological control of pests, diseases

and weed are instead recommended. Secondly, the use of toxic substances that pollute the environment is discouraged. Agroecology shows how crops and animals can be protected by non-chemical means such as polyculture and Integrated Pest Management (IPM) to result in higher yield per hectare comparable to conventional agriculture (Fernandes et al., 2005, pp. 327-329). IPM is a strategy for pest management that focuses on long-term prevention of pests or their control through such techniques as: biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties. The use of pesticides under this regime is restricted to removing targeted organisms and this is done according to established guidelines to minimize risks to human health, beneficial and non-target organisms and the environment (Eicher, 2003a). The core principles of IPM have been successfully incorporated into mainstream agricultural models. Through such methods, agroecology challenges the assumption that agricultural output will decline if conventional agriculture is not promoted to the maximum (Avery, 1995). Thirdly, organic matter such as crop and animal residues/compost, and manures are used to manage nutrients instead of chemical fertilizers. In relation to the above, minimum tillage is encouraged and the use of cover crops and green manures so as to reduce soil erosion and water/moisture/nutrients loss. Also, soil fertility is maintained and enhanced by promoting soil biological activity. Also, high species and genetic diversity is maintained so as to provide ecological services and increase the agroecosystem's resistance and resilience to changes (SARD, 2007). "The ultimate goal of agroecological design is to integrate components so that overall biological efficiency is improved, biodiversity is preserved, and the agroecosystem productivity and its self-sustaining capacity are maintained" (Altieri, 2002, p. 4).

Agroecology also promotes: the empowerment and farmer participation of indigenous peoples; building on successful methods and local knowledge about biodiversity and genetic resources; conservation of plant and animal genetic resources; creating supportive policy environment – eliminating incentives for uniform varieties (Thrupp, 2000, pp. 275-276). The interest in indigenous systems is not simply due to considerations of sustainability but also because millions of people in many developing countries continue to rely on these traditional systems, that employ ecological knowledge, for meeting their food needs (Wilken, 1987; Altieri, 1990). According to Altieri (1990) such traditional systems are not backward as they demonstrate sound ecological knowledge and with them, the concern in agroecology is long-term sustainability of the system rather than profit and out-put maximization.

The importance of the local knowledge to agroecology is twofold: first, local knowledge is contextual and knowledge of this context can enrich our understanding of existing natural

ecosystem structure. Secondly, agroecology relies on local farming experiences derived from years of living and working within the limits of a particular place (Gliessman, 2005, p. 109). Traditional systems exploit natural processes in the ecosystem and thus are able to maintain productivity over time without recourse to large external inputs and without serious environmental degradation. Agroecology builds on this system and offers alternative ways of increasing production in ways such as the promotion of polycultures as against monocultures of conventional agriculture. This means that more yields per land unit is possible when compared to those produced from monocultures (UNEP, 2005).

There is a growing realization that the production output of traditional systems can be increased to meet their food needs through a careful application of modern science and agroecological principles. This is true not just for smallholders for whom agroecology is a way of life but even for larger farms. Studies have shown that when large production systems incorporate these agroecological principles and practices, such as crop rotations, intercropping, use of cover crops, IPM techniques, green manures among others, they stand to benefit (Finch and Sharp, 1976; UNEP, 2005). In a similar study of 286 agroecological interventions in 57 developing countries since the early 1990s, Pretty et al. (2006) discovered that these traditional agricultural system had increased productivity by 64 per cent, with 25 per cent of them at least doubling yields (see also Pretty, 2002). What stands out in these studies is the awareness that traditional practices such as “intercropping, agroforestry, and other diversification methods mimic natural ecological processes, and that the sustainability of complex agroecosystems lies in the ecological models they follow (Pretty 1994 in Altieri, 2002, p. 4).

A similar awareness underlying agroecological studies is a related point that simply increasing food production/output as pursued by conventional agricultural systems is *not sine qua non* for hunger and poverty eradication. As already noted, conventional agriculture has achieved high output and yet hunger remains. Hence, agroecology takes the initiative of hunger eradication from agricultural enterprises/companies and places it instead in the hands of small farmers. Already possessing a rich repertoire of knowledge that stems from experience, these farmers are given more access to technologies and productive resources so as to increase local food production in ways that are sustainable. There is growing evidence which shows the potential of agroecological technologies to contribute to food security on many levels (UNEP, 2005).

An additional strength of agroecology is its emphasis on the importance of biodiversity in agricultural production. Biodiversity serves a number of functions which include: an increase in diversity and sustainability through improved interactions between species; efficiency in resource

use and system-level adaptation to habitat heterogeneity through species complementarities; resistance to herbivores due to diversity of natural enemies; the creation of diverse microclimates which can be occupied by diverse non-organisms that benefit the entire system; conservation of the biodiversity of the surrounding natural ecosystems; soil diversity benefits services like nutrient recycling and detoxification; a diverse ecosystem helps reduce risk for farmers in marginal areas with unpredictable environmental conditions (Altieri, 2002).

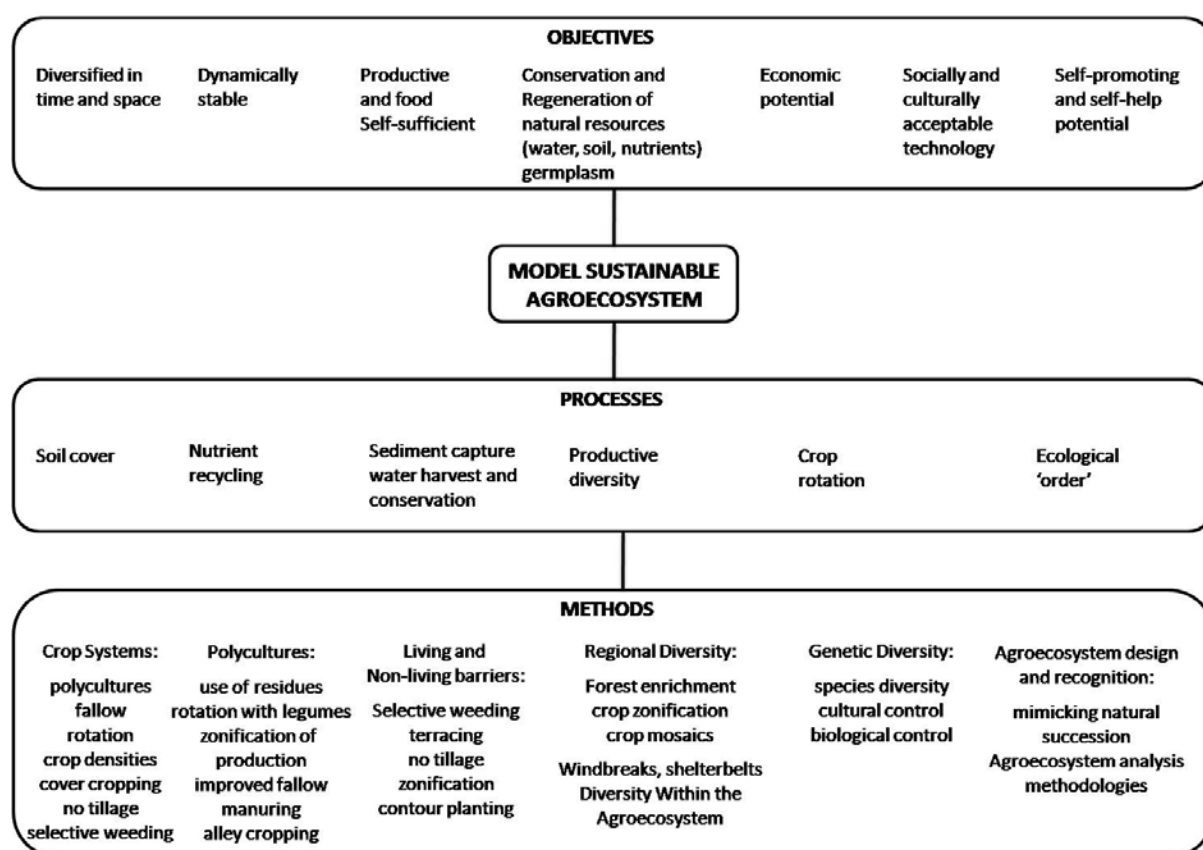


Figure 33: Model of sustainable agroecosystem
Source: (Altieri, 1989)

7.7 Agroecology, Smallholders and Food Security in Developing Countries

Many of the world's rural poor are smallholder farmers predominantly living in South East Asia and SSA (Kydd, 2002; Bithal et al., 2005). The proportion of the population living in poverty in smallholder farming has increased in SSA (Johannesburg Summit, 2002; Chen and Ravallion, 2004; Lipton, 2005a). These smallholders derive their livelihoods through cultivation of small portions of land and supplementing that with income from other related activities – poultry, fish farming, etc. However, as reflected by findings in this research and the discussion above, the ability of these smallholders to feed themselves is continuously challenged by global forces (natural and man-made) beyond their control. The global food system, largely shaped by industrial agriculture and globalization, has impacted negatively on the environment and human health and in many cases

disrupted traditional rural livelihoods. Despite these effects, this model of food production is still widely proposed for developing countries (e.g. The New Green Revolution for Africa advocated for by Alliance for a Green Revolution in Africa (AGRA)) and this has the potential to increase the dependence of poor farmers on foreign inputs as happened in Latin America and Asia.

Agroecology responds to these global trends by proposing the application of ecological principles in the design and management of agricultural ecosystems. This framework blends modern agroecological science and indigenous knowledge to assess the complexity of agroecosystems. This stems from the realization that by building on available local resources, varieties and indigenous knowledge, smallholders in developing countries have, over the centuries, built resilient and genetically diverse farms which enabled them to withstand the vicissitudes of climate change and dangers posed by pests and diseases as seen in findings in this research (Denevan, 1995). As a result, traditional methods of resource management have persisted over the centuries attesting to the astuteness of their principles and strategy. They continue to provide the basis of livelihood for millions of people all over the world. Agroecologists argue that new models of agriculture should draw from “the ecological rationale of traditional small-scale agriculture, representing long established examples of successful community-based agriculture (Altieri, 2009). Using agroecology principles, they further maintain that it is possible to optimize the productivity and sustainability of these traditional agroecosystems and thus provide the basis for a more just and equitable system that guarantees food sovereignty. This concept “emphasizes farmers’ access to land, seeds and water while focussing on local autonomy, local markets, local production-consumption cycles, energy and technological sovereignty, and farmer-to-farmer networks (Ibid.).

7.7.1 A Portrait of Smallholders and Smallholder Agriculture

Smallholders, as revealed by findings in this research, are crucial in achieving regional food security. Global figures show that in the 1980s, about two-thirds of Latin America’s total rural population are smallholders accounting for “41 per cent of the agricultural output for domestic consumption and for producing at the regional level 51 percent of the maize, 77 percent of the beans, and 61 percent of the potatoes” (Altieri, 2009). Analysts argue that the contribution of these smallholders has remained crucial over the last two decades. Figures from Asia show that the bulk of smallholders are found in China, India, Indonesia, Bangladesh and Vietnam. In fact, about half of the world’s small farms (193 million hectares) are said to be in China. The bulk of the smallholders in Asia are involved in rice cultivation using methods dating several centuries to cultivate between 0.2 to 2Ha (Hanks, 1992). In Africa, the number of small farmers is estimated to be 33 million (about 80 percent of all farms in the region). Majority of these smallholders are women depending

on traditional management techniques as those encountered in Karshi and Baddeggi to meet their food needs. Despite declining food production per capita production in Africa, smallholders continue to play a vital role both in food production but also in the production of cash crops (Asenso-Okyere and Benneh, 1997).

Despite their huge numbers and diverse characteristics, homogenization has characterized. Also, smallholders have often been maligned and thought of as an unproductive mass with “an intermediate technology of the plough and draft animals, living in a state, and subject to demands for tax or tribute from other elite groups in the complex society” (Netting, 1993, p. 7). Often, they have been described using negative attributes (e.g. as resource poor, under-developed, disadvantaged, peasants, pre-capitalist subsistence farmers, petty commodity producers, rural proletarians, low income, etc.) or using other relative terms lacking in any operational content (Harwood, 1979). According to Netting (1993), most of the literature classifies smallholders as ‘peasants’ and defines them by what they don’t do instead of what they do. Thus, the diverse groups of smallholders have often been grouped together as a homogenous bunch in property and wealth (Redfield, 1941; Redfield, 1955). Smallholders were viewed as being economically and politically inert – what Marx referred to as a mass of homologous magnitudes, much as potatoes in a sack form “a sack of potatoes” (Marx, 1971).

This way of defining smallholders has been described as inappropriate because they do not offer conceptual and operational models that explain the wide ranging differences within and across countries (Vincent, 1982). Critical literature on smallholders initially viewed farms as subjects to stages of transitional development from subsistence farms to fully commercialized farms. Nakajima (1969) defined farms based on the extent to which they are subsistent and the extent to which they are family or non-family. The two criteria in defining a farm according to Nakajima are; (1) the proportion of all produced consumed by the producer and his household and (2) the proportion of all labour in farm production that is provided by the household. By concentrating attention on subsistence and labour aspects of a farm, small farms are frequently said to have the following characteristics: (1) complex and diversified cropping systems to meet family food requirements (2) dependent on family labour and on a few occasions, hired labour (3) compete for cash between production and family consumption needs (4) utilize crop and livestock by-products (5) rely on community support systems (6) there is a precedence of food supply over profit maximization (Vincent, 1982). Subsequently, Owen (1974) developed the relationship between subsistence versus commercial farm paradigm and productivity and showed that small farms are as productive as large farms.

At present, smallholders are understood not as a homogenous group but as diverse and varied, including a wide array of rural people who practice intensive, permanent, diversified agriculture on relatively small farm areas of dense population. Smallholders thus defy all simple generalizations and demand their own explanation. According to Netting, an attempt must be made to “examine the ecological relationships of population, agricultural technology, household organization, and land tenure that characterize a distinctive smallholder adaptation to local environment (1993, p. 21).

Regardless of definition, however, smallholders are generally understood to have certain key characteristics. An important defining attribute of smallholders is farm size. Most smallholders around the world cultivate between 0.2ha to 4ha, a trend which has remained constant in developing countries between 1930 and 1990 and is likely to remain unchanged for some time in the future (FAO, 2004a) (fig 34). Smallholders are thus distinguishable from landless farming households and shifting cultivators. Even though subsistence is the basic motif for smallholders, they often participate in the market either through selling of agricultural goods or participation in off-farm sectors (such as cottage industry). Decision making on most small farms relating to time allocation, tools, and land, is done on a daily basis. Thus, Netting (1993) argues that smallholders are akin to Max Weber’s ‘ideal type’, that is “a conceptual pattern [that] brings together certain relationships and events of historical life into a complex, which is conceived as an internally consistent system” (pp. 2-3).

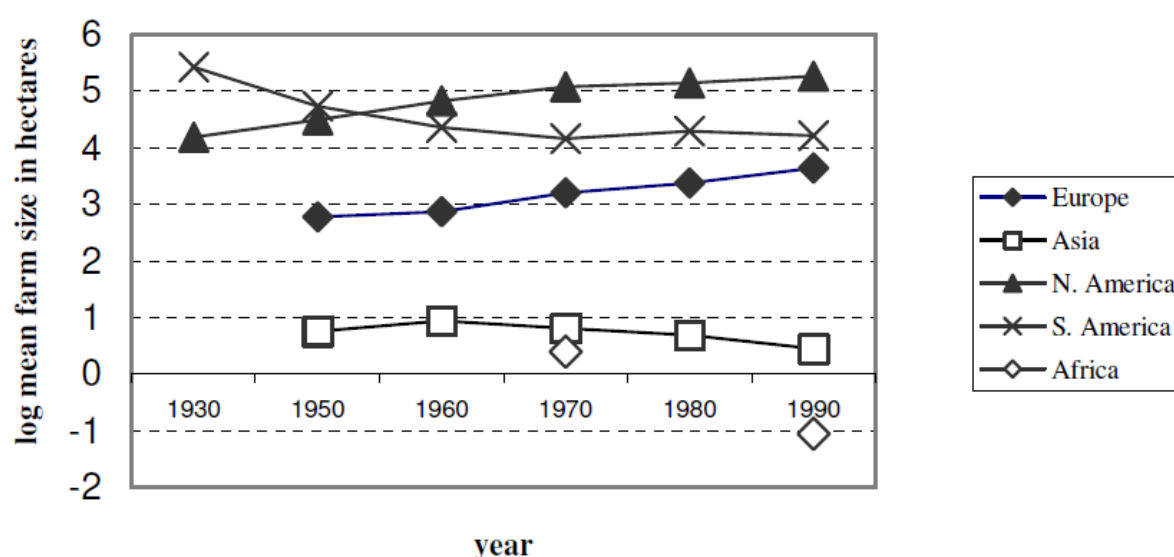


Figure 34: Mean farm size by continent, 1930-1990
Source: (FAO, 2004),

Another important feature of smallholders is the organizing unit of the family household consisting of a couple, their children, sometimes other kin and possible permanent employees. They live

together on or near their famers. The characteristics of these small agricultural producers, their family and households, include the following: relative stability and independence because they produce what is needed for their subsistence; the basic unit of ownership, production, consumption and social life is the family (Netting, 1993). The needs of the family supersede those of the individual as seen in labour distribution between members of different genders within the family to ensure efficiency through interdependency (Segalen, 1983; Burton and White, 1987).

It is within the family household that smallholder agricultural labour is mobilized, resources are managed and consumption is organized. Similarly, smallholders are characterized by a definite and fixed pattern of land ownership. These fields are permanently cultivated throughout the year through intensive agriculture of multiple and/or inter cropping. Soil fertility is sustained by means of traditional practices such as crop diversification and rotation, animal husbandry, irrigation, drainage and terracing. This is not say however, that smallholders do not use external inputs such as fertilizers and pesticides. On the contrary, smallholder agriculture in many developing countries has expanded to embrace the use of such inputs. However, their use is often limited by availability and cost as was the case in Karshi and Baddeggi. Many smallholders continue to exploit the complementarities between crop and livestock enterprises and between farm production activities *per se*, and the processing of farm inputs and farm products by the farm household. In contrast to the “maximization of product specialization of labour saving techniques which typify the modernized, commercial farming sector, maximum employment opportunities in the subsistence sector are through the process of maximum diversification of production” (Owen, 1974, p. 32).

The success of smallholders is said to lie in their intimate knowledge of a given piece of land. This knowledge, even if particular, provides a general basis for efficient resource management. About two-thirds of all the agricultural holdings in the world are between one and five hectares. This means smallholders perform an important social welfare function by absorbing and feeding the surplus of rural population (Netting, 1993). For smallholders, land has other values that go beyond production and include attachment to land, a reverent disposition towards habitat and ancestral ways, a restraint on individual self-seeking in favour of family and community (Redfield, 1956, p. 63).

Just as in Karshi and Baddeggi, it has been shown that many smallholders (especially those with secure tenure) in several smallholding communities in Nigeria operate within the framework of common property regime (where resources are collectively owned and administered by the community) which guarantees co-equal ownership of resources like land and water in a structured manner so as safeguard food security and generate employment and income (Netting, 1993).

According to Ostrom(1990), common property regimes are typically characterized by the following principles: clear boundaries for the resource and its beneficiaries, correspondence between rules of appropriation and provision and local conditions, collective ownership and rules, mechanism of control or monitoring, a system of sanctions and incentives and mechanisms for resolving conflicts among others. Through these principles resources are acquired and managed for maximum outcome of the community which would have been impossible with just the individual.

In general, agricultural development policies and programmes in colonial and post-colonial Africa as well as donor actions did not favour smallholders and indigenous knowledge(Timmer, 2005). Ineffectual policies meant that smallholders were sometimes neglected or had their ability to produce and compete severely curtailed. Smallholders had little or no access to incentives and government policies on agriculture and rural development were fragmented and suffered from over-centralization and sometimes an urban bias leading to increased food insecurity and poverty (Murphy and Santarius, 2007). Similarly, investment in infrastructure was poor despite heavy taxation (Binswanger and Townsend, 2000). Thus, smallholders were under-represented and, in fact, harmed by many development policies and their role in promoting food security, reducing poverty and advancing economic development was ignored or misunderstood because they were considered to be inefficient. Similarly, agricultural sustainability was jettisoned in the quest for crop maximization through resource exploitation. African farming systems were marginalized and considered static and unproductive. Similarly, expert and scientific knowledge were considered higher than indigenous knowledge and hence the proliferation of policies that favoured 'technical' input.

Despite these constraints, however, African smallholders survived by adapting and exploiting opportunities presented by the mainstream agricultural models such as the adoption of new crops(Davidson, 1978; Richards, 1985). Since the 1980s, however, there has been an increased and concerted effort at repositioning traditional agriculture and indigenous knowledge systems as viable and sustainable alternatives to mainstream agriculture(Chambers and Howes, 1980; Knight, 1980; Richards, 1985; Stigter, 1987; Chambers et al., 1989; McClure, 1989; Brookfield and Padoch, 1994). Also, there has been a shift in focus to the rural poor and smallholders themselves and what they are *actually* doing in order to build on their practices and knowledge systems to guarantee food security and economic growth. Also, African smallholders and rural poor are now being understood to be as complex as the continent's geographies, social systems and economies. There has been an evolution in the perception of smallholders from a 'generic social type' to a multiple and contextually dependent unit (Cliffe, 1987). The contribution of smallholder

agriculture to agricultural/economic growth has been examined by numerous empirical studies. Small farms have been shown to be important in securing the livelihoods of poor households, reducing poverty and preventing urban migration (IFAD, 2001; Eastwood et al., 2004; Hazell, 2004; Lipton, 2005b). Some have argued that in order to maximize their potentials, smallholder agriculture has to be strengthened (Binswanger and Townsend, 2000).

7.7.2 Small Farms: Productivity, Resource Conservation and Agrobiodiversity

Smallholders have been considered unproductive and inefficient because of their isolation in rural areas, use of simple technology, and modicum of self-sufficiency, are removed from market and/or maximization of profit and private property. However, others have argued that whereas profit motivation may be the predominant consideration in modern agricultural societies, smallholders often have other considerations such as cultural attitudes, values and institutional arrangements. This means that smallholder economy requires analytic consideration not readily provided by formal, economic analysis (Schultz, 1974; Burling, 1982).

Most smallholders utilize the scarce land available to them and optimize per unit area production. Smallholders, in contrast to the larger farms that utilize “modern production techniques for the purpose of marketable surpluses for export or domestic consumption,” are composed of “small farming units whose output is just sufficient to support the immediate family’s consumption needs [and possibly sell whatever surplus there is]” (Biggs, 1974, p. 12).

One other reason why smallholders have often been considered as unproductive is because they are said not to produce large surplus for the market despite using too much labour and that they do not make rational economic and scientific decisions about production and innovation (Netting, 1993, p. 21). This perception has influenced much of development planning and policy from the 80s through to the present time. Those who argue thus insist that cash is the most important determinant of food security and not the ability to produce food as such. Therefore, commercialization of agriculture is advocated for as the surest way out of rural subsistence and poverty in developing countries (Hendriks and Lyne, 2003; Kistern et al., 2003). Others criticize any prioritization of smallholders as an attempt to achieve social justice at the expense of productive efficiency. The rationale behind this thinking is the assumption that there are economies of size in farming, making large farms relatively more efficient in the use of resources. This outlook continues to influence much of the policy on agricultural development despite evidence to the contrary.

However, studies have shown higher productivity *per unit of land* among intensive smallholders than the extensive, technologically advanced systems. Empirical survey from India and other developing countries shows the inverse relationship of farm size and land productivity – small farms produce more *per ha* through labour substitution for land, leading to higher yields and energy efficiency;(Sen, 1962; Bardhan, 1973; Khusro, 1964; Dorner and Felstehausen, 1967; Rao, 1967; Berry, 1972). These scholars argue that large farms use relatively less labour because they can only afford to pay employees up to the point where their wages equal the return on their labour, whereas household members on small farms get no wage and require only subsistence; they can continue to work even when their marginal products are below their wages. There is considerable evidence, consequently, to suggest that over a significant range of small farm sizes a negative correlation exists between farm size and land productivity(Georgescu-Roegan, 1960). Due to small few economies of scale (or even diseconomies of scale) in farming, small farms in developing countries have been shown to produce more per hectare than large farms (Cornia, 1985; Eastwood et al., 2004). Small farms are generally more efficient due to their intensive nature, relying on much labour which helps save costs of supervision typical of large farms. Also, small farms are often more efficient in the use of resources – land, water, biodiversity, etc. They also play a bigger role than large farms in equity and poverty reduction. “Smallholdings are typically operated by poor people who use much labour, both from their own households and of their (equally or more) poor neighbours. Moreover, when small farm households spend their incomes, they tend to spend this on locally-produced goods and services, thereby stimulating the rural non-farm economy and creating additional jobs”(Hazell et al., 2006).

One of the strengths of small farms is their flexibility and ability to adapt to pressures. This has been described by Geertz (1966) in the context of Indonesia as *Agricultural Involution*, whereby faced with external and internal pressures, local farmers in Indonesia intensified existing forms of agriculture rather than changing. This involved putting even more labour into paddy field cultivation, increasing per hectare output while maintaining per capita output. One other reason for the higher yield of small farms is continuous cultivation of the same land because of scarcity through practices such as interplanting, multicropping, and irrigation (Ellis, 1988, pp. 198-199).Such traditional multiple cropping systems are said to supply about 20 percent of the world food supply. For instance, in both Africa and Latin America, substantial part of all cultivated area is under polyculture. Through this system, smallholders increase their productivity per unit area making them more efficient than single crop large farms under the same management. “Yield advantages can range from 20 percent to 60 percent, because polycultures reduce losses due to weed (by occupying space that weeds might otherwise occupy), insects, and diseases (because of

the presence of multiple species), and make more efficient use of the available resources of water, light, and nutrients” (Altieri, 2009). By implication therefore, small farms are often more profitable because their profit margin per unit of output is higher. This is even more important considering the fact that smallholders achieve this productivity in a manner that exacts less damage on the environment due to the reliance of their farming systems on natural cycles which reduces soil erosion and preserves biodiversity.

Unlike high-cost commercial farms, small-scale family farms are low producers and less vulnerable to changes in markets, and access to cheap credit. Thus, smallholders respond well to improved incentives when prices are right and have been responsible both for most of food and cash crops produced in developing countries (Toulmin and Gueye, 2003). Additionally, smallholders use diverse production techniques instead of the product specialization of labour saving techniques of modern, commercial agriculture. Thus, natural cycles, complementarities between crop and livestock, are explored. Importantly, intensive smallholders are able to achieve rise in production while at the same time enhancing soil nutrients and maintaining a stable agroecosystem. From the practices of smallholders, it emerges that “intensive techniques when applied with care, and frequent monitoring of the field, garden or orchard, also imply a *sustainable* agriculture that prevents the erosion and degradation that frequently accompany large-scale extensive land use” (Netting, 1993, p. 8). Also, through experimentation, smallholders develop knowledge not in a static but dynamic sense, for instance their knowledge of genetic diversity of local varieties, soil, topography and irrigation.

By producing subsistence crops, small farms have advantages especially in most of Africa where obtaining staples from the market involves significant costs and risks. However, it has been pointed out that “countervailing economies of scale apply in procuring inputs, marketing output, obtaining credit and other financial services, in obtaining information on markets and technical issues, in meeting standards and certifying production, and in transacting with large-scale buyers from processors and supermarket chains with their exacting demands for quality, timeliness and bulk deliveries” (Wiggins, 2009, pp. 4). High transaction cost can therefore hinder smallholder productivity (Dorward, 1999; Poulton et al., 2005). In general however, due the substance nature of African agriculture, small farms have significant advantages over large farms.

Several detailed studies and historical reviews have shown agricultural booms (both in cash crop and food production) based on smallholder agriculture. Colonial agriculture in Africa was largely based on smallholders: cocoa in Ivory Coast and Ghana, groundnut in Nigeria, Senegal and Gambia, oil palm in Nigeria and tea and coffee in Kenya, Zimbabwe and francophone West

Africa (Poulton et al., 2004). There were similar growths in food production for domestic markets: hybrid maize in Zimbabwe, Tanzania and Zambia in the 1980s (Eicher, 1995), rice in the inland delta of the Niger (Diarra et al., 1999), open-pollinated maize varieties in central Nigeria (Smith et al., 1993), horticulture exports in Kenya (Minot and Ngigi, 2003) and peri-urban production of dairy, fruit and vegetables in Kano (Mortimore, 1993). On the other hand, there is an extensive literature on the failure of large farms in different parts of Africa: groundnut schemes for export to the UK in Kenya, Tanganyika and Northern Rhodesia (Johnson and Ruttan, 1994), mechanized farming in Gold Coast in 1951 (Eicher and Baker, 1982; Frimpong-Ansah, 1991), vegetables for export in Senegal (Chasm, 1982; Mackintosh, 1989). These examples, however, do not imply that all small farms are successful nor all large farms failures. However, large farms are not always technically or financially the better option (Wiggins, 2009). It is important to view smallholders as a separate and critical development unit possessing real and present economic opportunity. This means going beyond the traditional peripheral solutions to smallholder productivity to actually “expanding the existing subsistence farming opportunity, both in terms of the number of households it serves, and in terms of increasing the productivity of the land it utilizes” (Owen, 1974).

In addition to productivity and biodiversity conservation, however, evidence from this study and other previous studies show that small farms are important units of agrobiodiversity. Through the use of multiple cultivars, small farms are generally more genetically heterogeneous a fact which not only increases their productivity as seen above but also makes them less susceptible to shocks (Clawson, 1985). By maintaining biodiversity in traditional cultivars, smallholders are better able to build resilience to environmental changes which is more important to many farmers (as evidenced in Karshi and Baddeggi) than simply multiplying yield (Jordan, 2002). By trading these important traditional traits for transgenic qualities (e.g. herbicide resistance) as promoted by advocates of a new GR in Africa, there is the risk of reducing the stability of small farms and increasing their vulnerability. The resulting shortfall in local crops will have dire social consequences in many developing countries. Consequently, agroecologists argue for the protection of smallholder agriculture from GMO proliferation and thus preserve genetic resources which are crucial to smallholders especially in times of ecological failure (Altieri, 2009).

Another important advantage of small farms is their resilience to climate change. This is crucial given predictions that smallholders in developing countries, especially those in Africa, are likely to be the worst victims of climate change as demonstrated above. The persistence of smallholders over the years is largely due to their resilience and internal adaptation strategies which enables them

to withstand extreme climactic variations(Altieri and Koohafkan, 2008), a fact strengthened by findings from Karshi and Baddeggi. The adaptation strategies of smallholders include “minimizing crop failure through increased use of drought tolerant local varieties, water harvesting, extensive planting, mixed cropping, agroforestry, opportunistic weeding, wild plant gathering, and a series of other traditional farming system techniques” (Altieri, 2009). As seen in findings from this research, one of the most important assets of smallholders is the diversification of cropping systems which increases their productivity but also serves a guarantee in case of individual crop failure.

7.7.3 Enhancing the Productivity of Small Farming Systems Through Agroecology

Agroecologists seek to promote a system that can result in increased productivity by relying on existing natural resource assets and social capacity of smallholders (Pretty, 2004). This reliance on natural assets and services reduces environmental risks and increases independence through use of indigenous knowledge and skills. The main components of this model are summarized in the table (42) below. The potential of smallholders to ensure food security through sustainable agriculture has for long been recognized and advocated for by scholars on the margin of mainstream development discourse (Pretty, 1995; Altieri and Farrell, 1995; Thrupp, 1996). Agroecology promotes a type of agriculture that can contribute to poverty alleviation and food production by empowering the people who need food the most to produce it. To achieve food security means food is “available at all times, to which all persons have means of access, that is nutritionally adequate in terms of quantity, quality and variety, and is acceptable within the given culture” (Rome Declaration on World Food Security and Plan of Action cited in Madeley, 2002, p. 38). Inherent in agroecology is the realization that this cannot be achieved unless key questions of “who produces the food, who has access to the technology and knowledge to produce it, and who has the purchasing power to acquire it” are answered (Pretty et al., 2005, p. 375).

Improvement type	Description	Elements
Type 1	Finance	<ul style="list-style-type: none"> ▪ Access to credit, grants, subsidies ▪ Increased returns on sales of produce ▪ Attract new sources of money for natural capital (e.g. eco-tourism, hunting of wildlife)
Type 2	Better use of non-renewable inputs and technologies	<ul style="list-style-type: none"> ▪ Precision-farming, patch spraying, targeted inputs and slow-release for pesticides and fertilisers ▪ Low dose (and non-toxic) sprays ▪ Veterinary services ▪ Pheromones, sterile males ▪ Resistant crop varieties and livestock breeds ▪ Machinery, handtools, ploughs ▪ New cash crops, including energy crops
Type 3	Better use of available renewable resources (natural capital)	<ul style="list-style-type: none"> ▪ Water harvesting ▪ Soil and water conservation – e.g. Contour cropping, terraces, minimum tillage, grass strips ▪ Composting, livestock manures ▪ Irrigation scheduling and management ▪ Restoration of degraded or abandoned land ▪ Rotational grazing ▪ Habitat management for pest-predators ▪ Drainage systems and sub-soiling ▪ Raised beds or chinampas ▪ Bio-pesticides and bio-fungicides
Type 4	Intensification of single sub-component of farm system	<ul style="list-style-type: none"> ▪ Double-dug beds ▪ Vegetables on rice bunds ▪ Kitchen gardens ▪ Fish ponds ▪ Micro-environment improvements, e.g. gully cropping, silt traps
Type 5	Diversify by adding new productive natural capital and regenerative components	<ul style="list-style-type: none"> ▪ Legumes in cropping systems (cover crops, green manures) and pastures ▪ Integrated livestock (e.g. poultry, stall-fed ruminants etc.) ▪ Fish in rice fields; Azolla in rice ▪ Trees in cropping systems, including woodlots ▪ Natural enemy releases for pest control ▪ Habitat management, e.g. hedgerows, beetle banks, flowering strips
Type 6	Social and participatory processes that lead to organised group action for making better use of existing resources and development of new skills	<ul style="list-style-type: none"> ▪ Farmers' research and experimentation groups ▪ Resource management and users' groups (e.g. forest protection, fisheries, irrigation, watersheds) ▪ Credit groups ▪ Horizontal partnerships between external sectoral agencies (e.g. government and NGOs; private and public)
Type 7	Add value by processing to reduce losses and increase returns	<ul style="list-style-type: none"> ▪ Post-harvest technologies ▪ Processing primary produce before sale (e.g. dried fruit, chutney, oil press, sawmills) ▪ Fuel-efficient stoves
Type 8	Add value by direct or organised marketing of produce to consumers	<ul style="list-style-type: none"> ▪ Farmers' markets ▪ Box schemes, farm shops and direct mailing ▪ Community supported agriculture ▪ Producer groups for collective marketing ▪ Rural roads and infrastructure

Table 42: Typology of improvements for sustainable agriculture
Source: (Pretty, 2004)

Despite the evidence that supports the role of smallholders as engines for growth and poverty reduction, some still argue that the focus on small farms will hinder large-scale poverty reduction. This argument is based on the assumption that smallholders and the institutions that support them are too weak to support the fast labour productivity that is needed for large-scale productivity

(Collier and Dercon, 2009). Instead, as demonstrated throughout this thesis, many favour agrochemical and transgenic intensification as the only way to ensure increased productivity. However, results from this research show that through effective use of ecological principles such as those found in traditional farming systems, it is possible to achieve the twin goal of productivity and sustainability. Agroecology provides the framework for the redesign of small farms in a way that enhances the habitat “so that it promotes healthy plant growth, stresses pests, and encourages beneficial organisms while using labour and local resources more efficiently” (Altieri, 2009).

There are three options in tackling the challenge of increasing agricultural development and food increase. One choice is to expand the area of agricultural production so as to increase food output. This option, however, leads to loss of ecosystems like forests and as a result an attendant loss in biodiversity. Alternatively, per hectare production can be increased in agricultural exporting countries. This option faces the problem of cost and efficiency in transferring the food from those who produce it to those who need it. Finally, there is the option of increasing total farm productivity in developing countries. In the past, agricultural research centred on the first two options – areas of production were expanded and specific crops were encouraged (for instance, high yielding varieties of rice, wheat and maize). The biodiversity losses were significant.

Agroecologists favour the third option for the following reasons: it aims to: “integrate natural processes such as nutrient cycling, nitrogen fixation, soil regeneration and natural enemies of pests into food production processes; minimize the use of non-renewable inputs; make productive use of knowledge and skills of farmers and; make productive use of people’s capacities to work together to solve common agricultural and natural resource problems” (Pretty et al., 2005, p. 377).

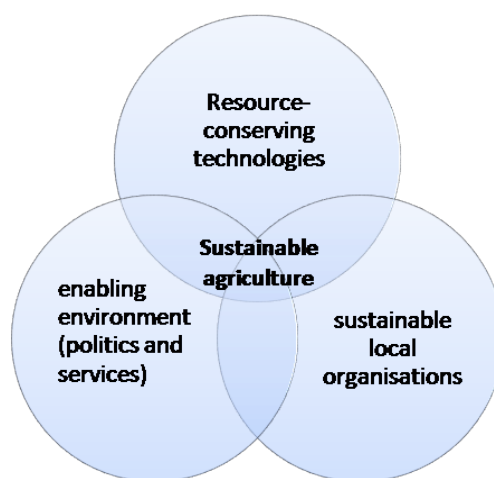


Figure 35: Conditions for improving sustainable smallholder agriculture
Source: Adapted from Pretty (1995)

Thus, agroecology offers a sustainable alternative to increasing food production while at the same time maintaining agricultural lands (especially marginal lands) that hitherto had been degraded by intensive and conventional agronomic practices. Similarly, through agroecology, low cost technologies and farming practices are developed to suit the specific needs of the poor, small producers in diverse environments; in particular it pays attention to the needs of women. Finally, it helps to “reverse the anti-peasant bias of strategies that emphasize purchased inputs as opposed to the assets that small farmers already possess, such as their low opportunity costs of labour” (Altieri et al., 2001).

Mounting evidence from different parts of the world shows that through the use of agroecological principles, the productivity of smallholders can be enhanced to cope with food demands in the midst of climate change, rising food prices and energy costs (Altieri, 1999; Uphoff and Altieri, 1999). In some instances, cereal yields were increased from 50 to 200 percent through use of the agroecological principles. The potential of agroecology have been documented to include: “increasing stability of production through diversification, improving diets and incomes, and contributing to national food security (and even to exports) and conservation of the natural resource base and biodiversity” (Altieri, 2009). A recent report of the United Nations Conference on Trade and Development confirmed previous findings on the potential of agroecology. In a review of 114 cases, the report found out that agricultural productivity increased by 116 percent in some cases and thus argued that food security in Africa can be boosted through organic agriculture (Ibid.).

Furthermore, in an extensive study by the University of Essex on sustainable agriculture in Africa, scientific evidence from 17 countries showed how sustained and systematic application of the principles of sustainable agriculture and the improvements discussed above has resulted in substantial increase in yields (Pretty, 2004). Recent studies in Uganda, (Gibbon et al., 2007), Ethiopia (Parrott and Marsden, 2002; Halberg et al., 2006; FAO, 2007) arrived at very much the same conclusion. It is not just in the developing countries of the South that the potential of sustainable agriculture to feed large populations has been demonstrated but also in the developed countries in the North where organic farming methods have been known to deliver as much yields as conventional farming with less damage to the environment (Mader et al., 2002; Pimentel et al., 2005).

However, in order to achieve food security through sustainable agriculture (SA), an enabling institutional framework (national) must first be created to promote the theory and practices involved in SA. Secondly, sound ecological practices in the area of natural resource management

and the conservation of biodiversity, already used by millions of smallholders in Africa, should be encouraged through sustained research and funding. The focus should be on researching, documenting, improving and expanding of the best practices in traditional agriculture such as farm management methods of crop and animal intensification that rely less on agrochemicals and more on organic methods. Additionally, there is the need for further technical training (and re-training) of smallholder farmers in Africa on sustainable farming techniques.

A recent report questions continued business investment in export-oriented, large-scale and foreign agribusiness at the expense of smallholder agriculture, local seeds development, diversification and local value-adding processing. It argues that instead of pushing technology-driven new GR and competitive export trade models that have previously characterized development policies in Africa, European institutions should rather enhance agroecological smallholder food production and support policies that protect local and regional markets and promote effective participation of social actors in the planning of agricultural policies civil society (European Civil Society, 2008). In general, the systematic exclusion of smallholder farmers from policy framework, erosion of traditional knowledge systems and the canonization of Western 'expert' and scientific knowledge has resulted in an asymmetrical power relationship between African smallholders on the one hand (who were being regarded as backward) and experts/policy makers whose opinions were considered absolute (Ochieng, 2002)

As already seen, the International Assessment of Agricultural Knowledge, Science and Technology (AKST) has made a strong case for the strengthening of agroecological sciences in order to increase agricultural productivity without harming the integrity of the environment. Central to achieving this, argues the report, is the utilization of indigenous knowledge in the area of soil, water and pest management as well as biodiversity conservation and resilience to external stressors. In order to realize the full potentials of agroecology and expand its reach, major changes in policies, institutions and research are required. The focus need not be just on increasing yield and the promotion of export crops but must also aim to conserve biodiversity and empower the poor through job creation and improved access to local inputs and markets. If research is devoid of input on local knowledge and skills then it ignores smallholders and the possible role they can play in food security. Thus research must encourage a participatory approach whereby smallholders are able to share their experiences (Holt-Gimenez, 2006).

A major challenge for many smallholders in Africa is water scarcity. To achieve SA, therefore, small-scale irrigation and indigenous water management systems and practices should be optimized and improved. Other means of ensuring increased food security through sustainable agriculture

will require elimination of obstacles faced by smallholders, especially women, such as lack of access to information and means of production (land, credit and market) and simple, sustainable and accessible technologies. Insecure land tenure poses a major problem to agricultural sustainability in developing countries (Gray and Moseley, 2005). An IFAD report (2003) showed the difficulty in adopting SA in developing countries where land ownership is tenuous and not guaranteed.

Another major constraint in adopting SA in many developing countries is soil fertility. Many farmers have come to rely on agrochemicals fearing a transitory decrease in yield in the event that they stop using them. Farmer education on the viability of SA methods is therefore needed in addition to making provisions to cushion the effects of transition to SA. The importance of re-educating farmers, especially in rural communities, on SA methods and practices is necessary given decades of imposed modern agricultural techniques which have eroded local institutions and knowledge (Pretty and Hine, 2001).

SA is meant to ensure economic as well as ecological and social balance. To achieve the first, the obstacle faced by smallholders especially with regard economic injustice and the barriers created by global system of market, needs to be challenged more vigorously than is being done in the SA movement at the moment. In order to achieve economic sustainability for local farmers, they need more than just access to market but protection from the big forces and multinationals that currently dominate that market (Raynolds, 2000; IFAD, 2003; Wilson and Rigg, 2003). By so doing, SA becomes more than just a rhetoric or a benign approach to agriculture but a radical critique and alternative to conventional hegemonic food systems (Bryant and Bailey, 1997). Furthermore, through improved local commercialization and distribution schemes and fair prices among others, smallholders can be linked with their counterparts and the wider population. However, this can only be achieved through increased investment and research in agroecology that is geared towards building on what smallholders are already doing. These measures “will generate a meaningful impact on the income, food security, and environmental well-being of all the population, especially small farmers who have been adversely impacted by conventional modern agricultural policy, technology, and the penetration of multinational agribusiness deep into the [developing] world” (Altieri, 2009).

Additionally, even though sustainable agriculture (for instance agroecology) is often discussed relative to smallholders, it should be said that its principles and the change it envisages is applicable to big farms and agri-businesses. The challenge for smallholders as well as commercial agriculture is on how to preserve the natural base through less reliance on external inputs outside the farm

system. Furthermore, the management of pests and diseases through internal regulating mechanisms as advocated for by SA can be beneficial to both groups.

Recognition of the value of smallholders and traditional agricultural systems does not negate the fact that they face their own unique problems when it comes to the question of sustainability. For instance, it cannot always simply be assumed that all traditional farming practices are ecologically sound. Each case must be investigated on its own merit. Consequently, sustainable agriculture is not just as a return to subsistence but a blend of innovations originating from both scientists and farmers. As aptly put by Parrott and Kalibwani (2004), the challenge is to model and present the agro-ecological agricultural system in such a way that it enhances and manages rather than simplify the complexity of the eco-system and the biophysical interactions on which agricultural production depends. Also, it should integrate and exploit naturally occurring beneficial interactions. “But most importantly, organic farming in Africa must be seen as a process of learning and adaptation as well as the institutional and policy framework that drives this process” (p. 57). The new agricultural system should incorporate the principles of health, ecology, fairness and care.

Finally, despite the desirability of the science of agroecology, the field is still young and studies on conversion to sustainable agroecosystems are still very limited (Swezey et al., 1994; Hendricks, 1995; Gliessman et al., 1996). A lot needs to be done by way of research in order to improve yields and manage pest, as well as improve the indicators of sustainability (Gliessman, 2002). Also, since agroecology is not a single set of practices or technological package that can be applied the world over (FAO, 2003b), a challenge lies in adapting its principles to different local settings. Sustainable agriculture must be flexible and adaptable to local conditions, and must be able to persist over time without jeopardizing the productive capacity of the environment (FAO, 2003; UNEP, 2005). As Pretty (2002) has observed, the promises of sustainable agriculture notwithstanding, it is hard to tell if these models of production would be appropriate for or adopted by all farmers worldwide. The trade-offs in a transition to sustainable agriculture are yet to be fully studied.

7.7.4 The Future of Smallholder Agriculture in Africa and its Role in Food Security

In an increasingly globalized world, smallholders and smallholder farming are facing unprecedented challenges. Some have argued that smallholders have no future in Africa mainly because of their diversity, limited investment potential and differential ability to respond to market opportunities. As a result, many argue for large-scale farming and the ‘modernisation’ of agriculture, especially in Africa.

On the other hand, this policy direction has been questioned and its appropriateness debated due to the centrality of smallholder agriculture (or family farming) in livelihood provisioning in Africa. In addition to its economic value, smallholder agriculture defines rural existence as it encompasses social, cultural and spiritual values and benefits. “It provides the means for both social and economic production and reproduction” (IIED, 2005). This makes smallholder agriculture crucial in increasing productivity as well as reducing hunger. On the other hand, some have questioned the exclusive focus on smallholders and argue instead for a much more open-minded approach to different modes of production. They envisage a crucial role for large-scale farmers as commercial enterprises, often in interaction with smallholders within an institutional framework that encourages vertical integration and scale economies in processing and marketing (Collier and Dercon, 2009). Such an argument assigns only a marginal future role for African smallholders in securing food security. This position is, in my view, ahistorical and ignores the persistence and significant role played by smallholders in rural areas of Africa. It also assumes that Africa must necessarily follow the same development trajectory as developed countries.

One of the reasons for the survival of African smallholders can be attributed to their approach to natural resources and production. Due to the view of land as having cultural and spiritual value rather than strictly as an economic asset, African smallholders manage land from a generational point of view and adopt sustainable environmental practices. Central to their practice of agriculture is minimizing risk (e.g. market changes) and vulnerability to environmental shocks (e.g. drought and climate change) through a diversity of activities: investing in and switching between a wide range of crops, experimentation with new varieties and exploring new niches while coping with severe constraints. These farmers are also integrated into social networks (cooperatives, farming organizations, labour-aid groups, etc.) which allows them to access labour and other resources and which also act as safety net in times of crisis.

Contrary to popular assumptions, smallholders, when given the opportunity, invest in land and other resources. Their capacity to compete is demonstrated by their continued growth despite declining prices. An extensive study²⁰ of smallholders across Africa clearly shows that they are neither unproductive nor backward. A study of West African family farms showed that despite mixed fortunes (with some farmers flourishing and others declining into more poverty) and challenges (e.g. policy changes and reduced government support) there has been a steady growth in smallholder African agriculture in the last 3 to 4 decades which has kept pace with population

²⁰Generally, the empirical record on smallholder performance is uneven and incomplete as demonstrated by Wiggins (2009). However, available records show substantial increases in marketed output of both food and cash crops based on small-scale farming. On the contrary, there is no tangible record to support generalized success with large-scale farms.

growth through diversification(Toulmin and Guèye, 2003). This also confirms other studies in SSA that confirm the success of smallholders in raising output (Guyer, 1997; Wiggins, 2000).

However, the flexibility and dexterity of smallholders has its limits as the harsh environment (aggravated by natural factors (climate change) and socio-political constraints) limits their ability to renew equipment, maintain soil fertility and discourages young people from remaining in this sector. The structure and character of agriculture has been transformed in much of Africa and as some analysts have pointed out, it is within this new environment that smallholder agriculture will have to survive. These changes include:

the power exerted by rapid urbanisation throughout the urban hinterland, with towns and cities providing markets, a source of income and economic opportunity; the changing structure of farm households, and growing individualism; diversification of incomes and activities, especially migration earnings; new crops and niche products; rising scarcity and value of land, especially in peri-urban areas; and the greater role of private sector operators in input supply, marketing and contract farming systems(Toulmin and Guèye, 2003).

Other changes include transformation of agricultural supply chains and the prevalence of HIV/AIDS especially in Eastern and Southern Africa, the difficulty of producing technical innovations for the diverse ecologies of Africa, the challenge of climate change and reduced financing for agriculture (Wiggins, 2009).

These changes present both opportunities but also challenges to smallholders in developing countries. For instance, smallholders (together with other sub-regional sources or imports from other major producers) are better placed to meet the changes in demand within the region for more diverse grains, fruit vegetables, meat and dairy produce – smallholders can also benefit from Asian economic growth and the pressure on commodity prices (Wiggins, 2009). Similarly, agricultural science is better equipped today to produce innovations than before. In addition, the voices of smallholders can now be better heard with the emergence of producer organisations. Wiggins (2009) further argues that the surge in biofuels production to replace increasingly cost fuel imports could present an opportunity to smallholders in some parts of Africa.

However, other changes such as certain trade policies (such as trade subsidies) severely limit the potential of smallholders to compete. As shown by this research and supported by related findings in West Africa, imports of certain foodstuffs, such as rice, has damaging effect on the market opportunities and prices gained by rice farmers in West Africa. These farmers face the dual problem of being unable to compete with subsidized imports and additional constraints

which restrict their production (IIED, 2005). Similarly, smallholder agriculture is undermined by low returns from investment, low prices, limited market access, uncertain transport, high transaction costs, and limited access to inputs (Toulmin and Gueye, 2003). The status of smallholder agriculture as the main provider of employment in rural areas means that its displacement has other impacts such as rural-urban migration.

Another challenge to smallholder agriculture is the emergence of new actors in land management mainly as a result of the promotion of policies that support the commercialization of agriculture. This new group of agricultural entrepreneurs [e.g. in Senegal, Mali and Burkina Faso] come from an urban background and benefit from favoured access to economic and political networks providing entry to land tenure, privileged access to strategic information and credit, close relations with support agencies and accumulation of significant sums of money in the non-farming sector (Ndao and FONGS, 2005; Telly et al., 2005; Ouédraogo, 2006).

Similarly, the recent wave in the outsourcing of food production by developed countries in developing countries in order to escape soaring market prices and guarantee their own food security poses serious threat to African smallholders. These countries offer in return development funds/loans, contracts and increased investment in infrastructure development. It has been estimated that since nearly 50m acres of farmland has been acquired by rich countries (Saudi Arabia, China, South Korea, Sweden, China, Libya, Jordan, Malaysia, Egypt, UAE, Kuwait, and Qatar) in poorer countries (Sudan, Tanzania, Cameroon, Pakistan, Ethiopia, Philippines, Madagascar, Nigeria, Zambia, Thailand, Cambodia, Ukraine, Paraguay, Uruguay and Zimbabwe) (Cotula et al., 2009; Vidal, 2009).

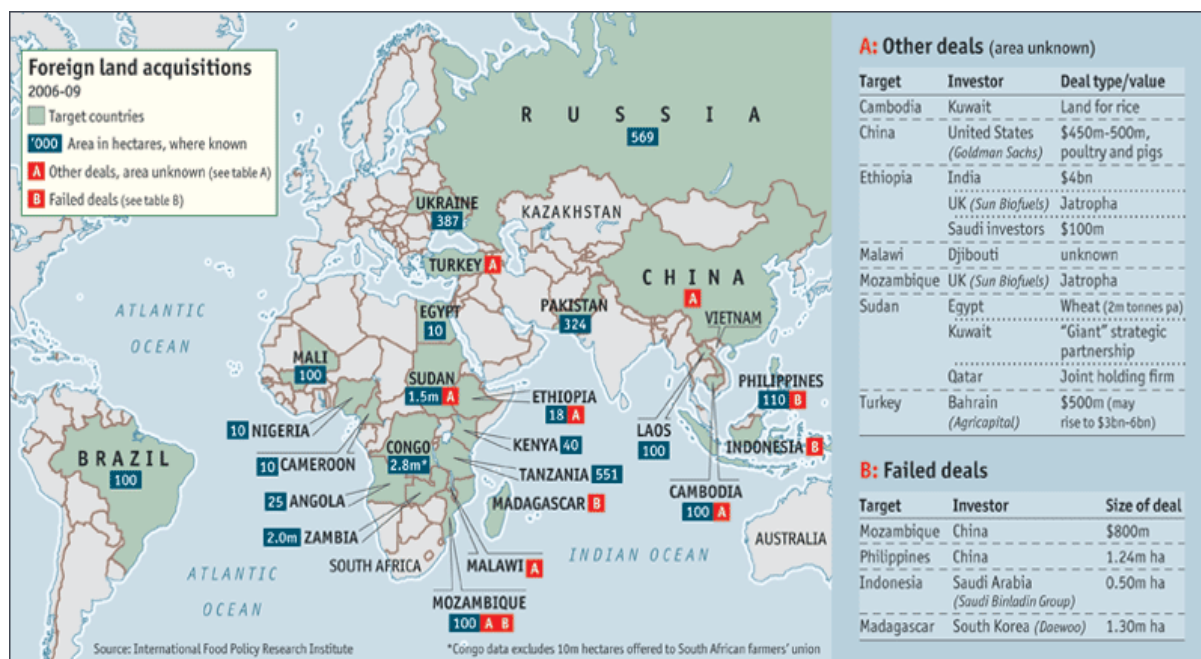


Figure 36: 'Third wave'²¹foreign land grab
Source: (The Economist, 2009)

Whereas foreign land acquisition is sometimes through legal expropriation (e.g. India, Philippines), in most cases it has been through forced leasing (e.g. India, Philippines, Indonesia), illegal grabs (e.g. Sudan), intimidation (e.g. Colombia, Uruguay), forced transfer of customary land by the elite (e.g. Pakistan, Cambodia) or 'legal' allocation of customary land without regard for customary rights (e.g. Tanzania, Mozambique, Ethiopia, Madagascar, Niger) (Taylor, 2009). This process has been described as a form of neo-colonialism and it has been tolerated and often encouraged by agencies such as the World Bank who pressure developing countries to change their land tenure laws to allow more ownership by foreign companies (Goldman Sachs, Morgan Stanley, BlackRock and Loius Dreyfus) (GRAIN, 2008). Some consider that the process could be harnessed to benefit the rural poor. They list the possible benefits that could accrue given the right policy and institutional frameworks and these include: economic growth and development through improved opportunities for improved livelihood and economic development; technology transfer, access to R&D, more accessibility to the market, increased investment in smallholder agriculture and rural infrastructure and increased food output (Taylor, 2009).

However, opponents have pointed to the threats that land grabbing pose to people's livelihoods and the environment: increased food insecurity due to increased food scarcities, biodiversity loss, reduced ecosystem functions and disruption of social institutions (von Braun and Meinzen-Dick, 2009). This is aggravated by the fact that sometimes the land acquired is used for the production

²¹ Land acquisition is not new. Waves of historical foreign or overseas land acquisition include the following: colonialism, contract farming, forced overseas resettlement and natural resource extraction.

of fuel and not food (GRAIN, 2008). It will also erode smallholder production models and further destroy indigenous knowledge systems. Other threats of land grabbing include environmental degradation through the perpetuation of inappropriate models of production that have led to the food crisis in the first place, asymmetrical relationship between the investing and the host countries, political instability and conflict (e.g. Madagascar) and negative consequences due to the transformation of rural communities (Taylor, 2009; Spieldoch, 2009). The process of land grabbing needs to be carefully studied and regulated to mitigate risks to smallholders. Also, the rights of indigenous peoples to land need to be strengthened as well their capacity to mobilize locally and internationally against forceful expropriation of their resources. Additionally, existing international framework and instruments should be expanded and new ones developed not only to protect the rights of poor smallholders but also to guide any process of land transfer such that both the rights of rural people and the integrity of the environment are safeguarded. The potential of foreign investment to stimulate agricultural/infrastructural development is desirable but this leads to land expropriation or unsustainable use, then it is unacceptable (von Braun and Meinzen-Dick, 2009).

In order for smallholders to ensure that their priorities are taken into account in new strategy and policies, it has been suggested that smallholders must organize and strengthen existing producer organisations to lobby their governments. Integrating smallholders into national/international agricultural policies means supporting their production and knowledge systems and enhancing them. Some have advocated for a pragmatic approach to provide greater security for smallholders and to encourage investment and productivity growth (Toulmin and Guèye, 2003). Significantly, it is further argued that the future of smallholders in Africa will depend largely on agricultural trade negotiations which can strengthen smallholder agriculture by creating easier access to markets in developed countries and cutting over-production and dumping by richer countries. Smallholders, however, need to expand their production base due to the lack of security associated with dependence on traditional export crops. They have already demonstrated flexibility in adapting to new crops and varieties and technologies. Another condition for smallholder development is improved investment in public goods supportive of agriculture – e.g. agricultural research and extension, rural infrastructure, education and healthcare (Fan and Rao, 2003) and effective economic institutions to reduce smallholder risk, protect property rights and facilitate trade (Wiggins, 2009). An important underlying condition is strengthening the ability of smallholders to conserve land, water and other natural resources so as to sustain physical production.

7.8 Agroecology: Merging the Goals of Productivity and Gender Equity

One of the important findings in this research is the role and centrality of women in smallholder agricultural production in developing countries and the plurality of functions they perform which are central to the survival of poor rural households. Such activities were found to be diverse including crop production, food and fuel provisioning. The central role that women play in agriculture in developing countries is now widely recognized in the literature. This is mainly due to the fact that women's role in rural households has grown in light of increased male migration to urban areas, a phenomenon now widely described as the *feminization of agriculture*. Despite the increase in the proportion of woman-headed households to almost one third in many developing countries, women continue to be marginalized in agricultural policies: they have less access to land, capital, credit and other social assets than men. In this section, the centrality of women to food security is examined and agroecology is used as a framework for promoting gender equality and empowerment of women.

7.8.1 Feminization and Empowerment in Smallholder Agriculture

The relationship between gender roles and agriculture is an intricate but essential one especially because of the number of women involved in that sector (fig 37) especially in developing countries where women are closely associated with agricultural production. To understand gender roles, a deeper examination of the differences in activities between different women and between different men as mediated by factors such as age, cultural perception, wealth and marital status, is required. Equally important is the roles women and men play in different stages of agricultural production and how these change over time. Thus, agricultural gender analysis looks at the complex social processes that are inextricably linked with power relations (Feldstein and Poats, 1989; CCIC, 1991; Overholt, 1991; FAO, 1995; Thomas-Slayter et al., 1995; Woroniuk et al., 1997).

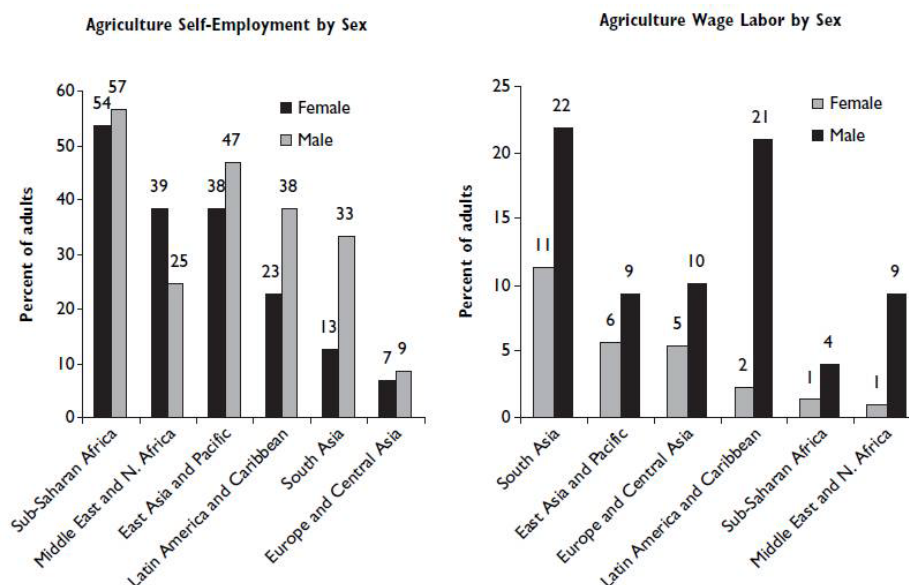


Figure 37: Rural employment by sector activity
Source: (World Bank, 2007a)

In many developing countries of the world, gender has important economic dimension, particularly as it relates to agriculture. Half of world's staple food (wheat, rice, maize) is produced by rural women, most of whom live in developing countries and account for between 60 and 80 per cent of the food in these countries (Bryson, 1982; ILO, 1984; Boyle, 1988). In sub-Saharan Africa, for instance, 80% of basic foodstuffs both for consumption within the household and for sale are produced by women²² (Henn, 1984; Boyle, 1988; Lele, 1991). Similarly, women provide labour on most farms through activities like sowing, weeding, fertilizer and pesticide application, harvesting and threshing of crops and food processing and storage. In Southeast Asia, for example, women provide up to 90% of the labour for rice cultivation. This is in addition to their even greater contribution to secondary crop production, such as legumes and vegetable. In pastoral communities, they also feed and milk animals, raise poultry and small animals. Despite their input to agricultural production, women are greatly disadvantaged and they barely own lands in most developing countries (only 10% in India, Nepal and Thailand) and receive negligible credit (10% in many African countries) when compared to their male counterparts. Also, only 15 per cent of the world's agricultural extension agents are women (FAO, 2005).

The role that women play in agricultural production has increased in the last decades in many developing countries. The effect of this is more on smallholders as women become principal farmers in the absence of men (Lastarria-Cornhiel, 2006). In sub-Saharan Africa, for instance, high rates of mortality of working men due to HIV/AIDS and rural-urban migration of men searching for better opportunities, means that more women are heading and providing for households. For

²²90 per cent of women in SSA are farmers

example, between 1970 and 1990 the rural male population plummeted by 21.8 per cent in Malawi while the rural female population declined by only 5.4 per cent. In Southern Africa, female-headed households represent 42 per cent of the total and in the Caribbean they represent 35 per cent (United Nations, 2000, pp. 42, 46-50). This phenomenon has been described as the *feminization of agriculture*, i.e. increased participation of women in the agricultural labour force as independent producers, unremunerated family workers or as agricultural wage workers (Katz, 2003, pp. 33-35; Deere, 2005, p. 17). This increased involvement of women places considerable responsibility on them and strains their capacity to provide food either for their households or for sale. The role of women in agro-exports has also increased. In Uganda, for instance, women labour is as high as men's and family adult labour ten times that of hired labour (Kasente et al cited in Dolan and Sorby, 2003, p. 51). The same situation obtains in Kenya where women input in both food and cash crop (coffee and tea) production is significantly high (Njuki et al., 2004).

This change of trend in gender role and division of labour has been linked with the neo-liberal policies experimented with in most developing countries since the early 1980s.

Fiscal stabilization policy sought to correct balance of payments problems, reduce inflation rates, and increase exports. Accompanying stabilization, structural adjustment policy included import liberalization, privatization of government sector resources and services, and liberalizing the labour, land, and capital markets. These policies have changed the type of export agriculture practiced (high-value agricultural exports have replaced traditional lower-value exports), the type of wage labour demanded by commercial agriculture (a seasonal and temporary labour force rather than permanent labour force), and the viability of smallholder agriculture (Lastarria-Cornhiel, 2006, p. 4).

One of the effects of liberalization on smallholders producing most of the food for local and regional markets was higher input costs and cuts in access to credit and extension services. This problem was compounded by increasing land scarcity especially in sub-Saharan Africa (Deere, 2005). Increased concentration, ownership and scarcity of land for the production of food seriously threatened many households. Liberalization also diminished agriculture, especially smallholding thus making it less valuable. Household members in developing countries were forced to migrate and seek off-farm opportunities. Thus the task of providing food and meeting other social responsibilities such as educating the children fell more on women (Mtshali, 2002, p. 87). Often, this means that women have had to adapt and be flexible in order to cope with labour and capital shortage. In some cases, this has led to decrease in production and shift towards less nutritious crops.

However, the *feminization of agriculture* does not always translate to empowerment. Whereas in some cases and cultural contexts women's role as economic producers has resulted in more power in the household and community, in others women continue to be subordinate to men. Generally, women who receive direct wages as wage workers exercise more control over how that money is used and hence have more power within the household than unremunerated women family workers. An apparent difficulty with the *feminization of agriculture* is that women are forced to combine reproductive and other responsibilities as farm workers either through increased time in wage work or assuming responsibilities traditionally carried out by men, for example, cash crop production.

Despite the greater responsibility that changes in agricultural production has thrust on women, they still face immense problems such as limited or no access to land, credit, extension services and technology (ILO, 1984). Unfavourable land tenure systems means women neither own nor control land, a situation compounded by land privatization which resulted in women losing even their traditional usufruct rights under communal ownership (Lastarria-Cornhiel, 1997; Bruce, 1998). Equally, women's access to extension and research services and facilities are severely limited - a trend set to continue due to the privatization of research currently being promoted (Saito et al., 1992, p. 46). In the area of technology, it has been assumed that technology is gender neutral (Stamp, 1990) and women have been systematically side-lined in the design and implementation of technologies that they often expected to use (Ashby, 2002). Also, women are often excluded from credit which makes it difficult for them to overcome obstacles such as lack of labour and information (Lewis, 1984, p. 183; Blackden and Chitra, 1999). Unfortunately, it is very hard for women to overcome these obstacles because even their political and organizational rights are severely curtailed (Tenga and Peter, 1996; Hambly Odame, 2002).

The inadequate attention given to women in agricultural planning is partly due to decades of gender bias and gender blindness which were fostered by neo-liberalism. Policy makers and development planners generally perceive farmers as 'male' and discount the role played by women (Moser et al., 1993). Much of agricultural research and investment were focused on cash crop activities of Africa's men farmers. Agricultural policy makers generally assume a unified household where income earned by males is shared between family members. Gender dimensions are thus ignored as women are seen to be part of the African farming structure. Yet, evidence abounds that suggest the contrary (Boserup, 1970; Saito et al., 1992; Gladwin, 1997).

This homogenization diminished the specificity and relevance of local detail as well as the role of women. Ironically, the very failure of modern agricultural production is what has resulted in the

feminization of agriculture despite the fact that it had, in the first place, displaced and disempowered women. The effects of neoliberal policies devastated women the most. Yet, little attention has been paid to effects of conventional agriculture on women, leading to the “invisibility” of women. Degradation due to agricultural expansion has impacted negatively on the production capacities of families and thus on women in those families. Many women have been exposed to health hazards through pesticide application. Deforestation, for instance, has increased the burden of collecting fuel and fodder. Other environmental challenges like the decline in soil fertility and water availability also affects women. It is estimated that about 86 per cent of Africa currently suffer from negative nutrient balances that would cost over US\$1.5 billion per year to eliminate (Henao and Baanante, 1999).

However, there is a growing awareness that in the face of the underperforming agricultural sector in developing countries and the growing food crisis, smallholders, especially women, can play a central role in ensuring food security (Blackden and Morris-Hughes, 1993). In fact, women have begun to take initiative to develop and promote local expert materials in the field of agriculture (Duncan, 1997).

Agroecology recognizes the role of women in traditional agricultural systems as users, managers and preservers of biodiversity. The unique knowledge of women of the genetic resources for food and agriculture makes gender an important dimension in agricultural biodiversity conservation. In sub-Saharan Africa, women cultivate as many as 120 different plants in the spaces alongside men's cash crops. Many have argued that the core of the sustainability paradigm is women because of their intimate relationship with the environment, their communities and future generations. In many traditional societies, women play a key role in seed and crop selection for the planting season. In Nepal, for instance, it is the bride who brings traditional varieties of seeds into an area by virtue of marriage. Thus, women are instrumental in sustaining knowledge systems and access to networks (Ghale and Upreti, 1999).

7.8.2 Conclusion

Despite differences of opinion on what the causes might be, it is widely agreed that the global food economy in its present form is in crisis. It is also unsustainable in the long-term due to its reliance on non-renewable energy, biophysical limitations (climate change) and the unhealthy consumption pattern it promotes. The consequences of the crisis on developing countries, especially in SSA are dire. This has heightened calls for alternative and sustainable systems. There is also a renewed focus on smallholders, who provide the food needs of millions in developing countries despite the challenges and changing structure of production. I have argued in favour of smallholders because

of their prevalence, productivity, flexibility and centrality to African livelihood. Regardless of the slow growth in African agriculture (which have been blamed on various factors internal and external), and the prevailing challenges, there is a real possibility for Africa to develop its agricultural sector by harnessing the potential of smallholders and indigenous knowledge systems, rather than imposing structures and systems that are not in tandem with the peoples' socio-cultural values. As shown above, the evidence on the role of smallholder agriculture in ensuring food security and reducing poverty is solid. Enhancing smallholder productivity will entail (1) *stepping up* – improving investment in infrastructure, sustainable technology and facilitating access to credit and sustainable inputs; (2) *stepping out*– investment in non-farm economy, e.g. education, health care; and (3) *hanging in* – providing social protection and investing in technology for food staples) (Dorward, 2009). However, enhancing smallholder productivity needs to be done within a sustainable framework. Agroecology was suggested in this thesis as an integrative approach that combines the ecological, economic and social dimensions of the ecology of the entire food system. As evidenced by findings in the research communities and captured in the substantive theory – *agricultural hybridization*, the focus should not be on the development of exclusives but of linkages and complementarities. The future of agriculture will depend on how much it is able to harness indigenous knowledge on sustainability and combine that with the best stable practices of modern agriculture. Equally important is the need to involve women in agricultural policy planning because of the key role they play in agricultural production in developing countries.

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Appendices

Appendix 1: Interview Schedule

AGRICULTURAL SUSTAINABILITY AND PRODUCTIVITY OF SMALLHOLDER FLOODPLAIN AGRICULTURAL SYSTEMS: A CASE STUDY OF *FADAMA* AREAS OF NORTH CENTRAL NIGERIA

Introduction:

- ✓ Self-introduction, name and general affiliation
- ✓ **Purpose of Interview**

Thank you for accepting to participate in this interview. This research is interested in *Fadama* farming in this community. I am interested in knowing how *Fadama* farming meets the conditions of sustainable agriculture (i.e. through use of resource-conserving technologies, enabling external institutions, local institutions and policy framework) and how it helps in poverty reduction. I assure you again that you will remain completely anonymous and no records of the interview will bear your name except with your permission.

- ✓ **Consent:** I will make sure that the interviewee understands and accepts the terms/conditions of interview, e.g. the use of tape recorders. I will answer any questions s/he has and clear her/his doubts regarding anonymity and oral consent
- ✓ **Confidentiality:** The interviewee will be assured that all their recorded replies will be confidential and their identity will be protected throughout the whole process – interviewing and transcribing
- ✓ **Anonymity:** No document will bear their names as their responses and the documents used in the interview will be codified and only those codes will be used. Anything suggestive of their identity will be omitted and only the researcher will know their identity
- ✓ **Control:** The interviewee is given power and control over the interviewing process and s/he is free to interrupt the interview, refrain from answering any question without having to give a reason, amend or qualify their answer.
- ✓ Audio tapes/video recordings from the interview will be kept for five years in a safe at the researcher's institution and then will be erased.

Interview Begins: Questions will move from the broad (general) to the specific (particular)

Appendix 2: Interview Questions

Section A: Biographical Data & General Demography			
No	Question	Prompt/Instructions	Variable
1	Age		
2	Gender		
3	Educational Level		
4	Marital Status		
5	Number of children		Household composition
6	Total number of people currently living in your household		Household composition
7	Of these, how many are family members and what is their relation to you (Interviewer: For all members of the household, note relation to interviewee)	Explain	Household composition
8	Are there non-family members living in the household?		Household composition
9	How many farms do you have?		
10	What are the sizes of these farms?		
11	How is land distributed/owned in your community?		
12	How many hours on average do you spend on the farm every week?		Frequency
Section B: Economic Status			
13	Is <i>Fadama</i> farming your only source of income?	Elaborate	Other jobs/occupation
14	What other sources of income do you have?	Elaborate	Other jobs/occupation
15	Is your income sufficient to meet your basic needs and those of your family?	Explain	Other jobs/occupation/livelihood means
16	If no, kindly explain how you meet these needs?	Elaborate	Other jobs/occupation/livelihood means
17	How many dependents do you have?		Household composition
18	Has any of your dependents migrated to the city? If yes, how often do they come back?		Household composition/migration
19	How has the <i>Fadama</i> farming project (I, II, II) and the use of new methods such as simple irrigation increased your output	Explain	Output increase
20	What is the labour demand for your farm? How do you meet this? Do you employ workers? How many? How much do you pay them?		Demand for labour and wages/employment
21	How is labour organized on your farm? Do you engage in labour exchange/cooperation?		Demand for labour and wages/employment/cooperation
22	What type of crop(s) do you produce?		Crop type
23	How much of these crop(s) do you consume and sell?		Subsistence/income
Section C: Sustainability: Resource-conserving/appropriate technologies			
24	What type of tools do you use? To what extent?	Can you please elaborate?	External input Extent of use of green technology adoption

25	How many of these tools are traditional and how many have been introduced through the <i>Fadama</i> project?		External input Extent of use of green technology adoption
26	What is the cost of these tools and how do you afford them?		Price
27	Is there collective ownership/means of buying these tools?		
28	How would you compare your traditional tools and the 'new' ones?		External input and traditional technology
29	Do you use of chemical fertilizers? If yes: How often; what type If Not: How do you treat infections, diseases, etc.?	Can you give me examples of this?	External input Indigenous crop/disease knowledge
30	Do you use pesticides? If yes: How often; what type? If Not: How do you treat infections, diseases, etc.?	Can you give me examples of this?	External input Indigenous crop/disease knowledge
31	What type of seeds do you use? If you use hybrid seeds, how do you compare them to traditional seeds?		Seeds/external input
32	What managerial skills/techniques/practices do you utilize in water conservation?		External input/traditional knowledge
33	What managerial skills/techniques do you utilize in soil conservation?	Explain	Traditional techniques
Section D: Enabling external institutions			
34	How open are organizations/government to input from you and your farming community?	Please elaborate	Multidisciplinary outlook of development organizations
35	Have you ever participated in any agricultural research? If yes, what type?	Please describe the research	Participation/support with local people
36	Do you participate in agricultural extension? If yes, how often?	Please describe what you do	Participation/support with local people
37	What other development activities and services have you participated in? (planning and implementation)	Please elaborate	Participation/support with local people
38	What do you think of agriculture officials?		
39			
Section E: Local Institutions and groups			
	How involved is the local and community in decision making?	Explain	Level of community action
40	How is the relationship between the local groups and outside groups?	Elaborate	Cooperation
41	How are local groups involved in coordinated resource management? (e.g. community organizations, farmer research groups, farmer to farmer extension, etc.)	Elaborate/give examples	Motivation/collective decision making
Section F: Enabling Policy Environment			
42	How does the current policy framework(s) encourage types of farming that are less dependent on external inputs and technologies like yours?	Give examples	Favourable policy for sustainable agriculture
43	Does the current policy framework(s) encourage, support and sustain change?	Give examples	Favourable policy for sustainable agriculture

	If not, how can it be made to do so?		
44	How much monetary assistance is given to you and other farmers?	Elaborate	Favourable policy for sustainable agriculture/credit
45	How do you feel about the terms of trade in the market?	Elaborate	Favourable policy for sustainable agriculture/trade terms
46	Do you sell directly to marketing boards or through middlemen?		Trade terms/conditions
Section F: For Policy Makers			
47	Who produces such technologies and for what purpose?	Explain	Policy generation and technology development
48	Are they likely to benefit poor and small farmers in the developing world? If yes, how will such farmers have access to the technology?	Explain Give examples	Policy generation and technology development
49	What are the effects on the environment, on human health and food security? What of the fundamental ethical issues?	Elaborate	Policy generation and technology development
50	How reliable are the regulatory systems and standards to control such technologies?	Elaborate Give examples	Policy generation and technology development
51	How does local knowledge contribute in the design and implementation of these technologies	Give examples	Policy generation and technology development
52	Does policy making take into account multiple perspectives which characterize most heterogeneous communities	Explain	Policy generation and technology development Local institutions and group involvement

About the interviewee and the interview

To be filled by interviewer:

1. Interviewee Identifier or name
2. Organisation
3. Sex
4. Date/time of interview
5. Duration
6. Location

Appendix 3: Consent Form

Participant's Name: _____

Date: _____

Informed Consent

1. **Title of study:** Agricultural sustainability and productivity of smallholder floodplain Agricultural systems: a case study of *fadama* areas of north-central Nigeria
2. **Purpose of:** To investigate how *Fadama* farming meets the conditions of sustainable agriculture/agroecology and how it contributes in poverty reduction
3. **Procedures:** I will be asked to answer/respond to questions about the study. The interviewing process will be scheduled at my own convenience, and will be conducted at a place of my choosing.
4. **Risks and discomforts:** There are no known medical/political risks or discomforts associated with this with this study. I will be given as many breaks as I want during the interviewing session.
5. **Benefits:** I understand that there are not direct/immediate benefits to me for participating in this study. However, the results of this study may help researchers gain a better understanding of *fadama* agricultural systems and how to make it more sustainable and productive.
6. **Participant's rights:** I may withdraw from participating in the study at any time.
7. **Financial Compensation:** I will not be reimbursed for my participation and any travel expenses.
8. **Confidentiality:** The researcher will record my responses using a recorder/writing in order to enable him to have a valid and reliable data (transcripts). The transcripts will be viewed only by the principal investigator and authorized members of the research team at the University of Bradford. I understand that the results of this research will be kept confidential unless I ask that they released. The result of this research may be published in professional journals or presented as professional conferences, but my record or identity will not be revealed unless required by law.
9. If I have questions or concerns, I can call Jake Dan-Azumi at **08059443717**

I understand my rights as a research participant, and I voluntary consent to participate in the study, I understand what the study is about and how and why it is being done. I will receive a signed copy of this consent form.

Signature of research participant

Date

Signature of researcher